Ecosystems services in developing economies: management, values and economic dynamic

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Les services écosystémiques dans les économies en développement: gestion, valeurs et dynamique économique

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Ecosystems services in developing economies: management, values and economic dynamic

Abstract

This thesis focuses on the economic valuation of ecosystem services in developing countries where environmental issues are considered a low priority. The general introduction defines the key concepts and presents the academic debates on the economic valuation of ecosystem services. The following two chapters deal with a specific case study: the urban park Bãngr-Weoogo in Ouagadougou (Burkina Faso). The first one analyzes the preferences of park visitors for the biodiversity and recreational activities through an empirical study based on the choice experiment method. The second one, with a similar method, analyzes the importance of green amenities in the residential location choice of Ouagadougou city inhabitants. This city, like many cities in developing countries, experiences a strong urbanization that has consequences in terms of housing and travel costs and in terms of environmental quality. The last chapter, which generalizes and analyzes theoretically the first study, integrates the importance of ecosystems in an economic growth model. Its main originality is to treat symmetrically ecosystem services and disservices to analyze the convergence conditions towards a balanced growth or a steady state.

Key words: biodiversity, choice experiment, economic valuation, growth models, Bãngr-weoogo Park, ecosystem services

Les services écosystémiques dans les économies en développement: gestion, valeurs et dynamique économique

Résumé

Les travaux présentés dans cette thèse portent principalement sur l'évaluation économique des services écosystémiques, dans un pays en développement où les questions environnementales sont considérées comme étant moins prioritaires. L'introduction générale permet de définir les principaux concepts mobilisés et resitue les débats académiques autour de l'évaluation économique des services écosystémiques. Les deux chapitres suivants s'appuient sur un terrain spécifique: le parc urbain Bãngr-weoogo à Ouagadougou (Burkina Faso). Le premier analyse les préférences des visiteurs du parc pour la biodiversité et les activités récréatives à travers une étude empirique basée sur la méthode du *choice experiment*. Le second étudie, avec une méthode similaire, l'importance des aménités vertes dans le choix résidentiel des habitants de la ville de Ouagadougou qui, à l'image de nombreuses villes des pays en développement, connait une forte urbanisation dont les conséquences se font ressentir tant au niveau des coûts de logement et de déplacement, qu'au niveau environnemental. Le dernier chapitre, qui généralise et analyse de manière théorique la première étude, intègre la question de l'importance économique des écosystèmes dans un modèle de croissance. Sa principale originalité est de traiter de façon symétrique des services et dis-services liés aux écosystèmes pour analyser les conditions de convergence vers une croissance équilibrée ou un état stationnaire.

Mots clés : biodiversité, choice experiment, évaluation économique, modèles de croissance, parc Bãngr-Weoogo, services écosystémiques

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[1] Maître Titenga PACERE, avocat et chef coutumier du Burkina Faso

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Chapter I: General introduction

Introduction générale

L'intérêt pour l'évaluation des écosystèmes ne fait que croitre du point de vue scientifique et politique. Le Millenium Ecosystem Assessment, (2001-2005) a mis en lumière les nombreux avantages que les humains retirent des écosystèmes et a surtout contribué à promouvoir le terme «services écosystémiques». Récemment dans la recherche, l'accent a été mis sur l'évaluation des services écosystémiques régionales et nationales ainsi que le développement de méthodes d'évaluation et les outils d'appui à la prise de décision économique.

Dans un premier temps, il importe de clarifier les concepts et les notions mobilisés tout au long de la thèse afin d'en préciser la portée et les enjeux. Il s'agira de présenter les dernières analyses autour du sujet et de mettre en relation les différentes parties de la thèse. Les services écosystémiques étant la pierre angulaire du sujet, ils font l'objet d'un développement particulier.

Notion de services écosystémiques

On attribue souvent à Ehrlich and Ehrlich, (1982) la paternité de l'appellation « services écosystémiques ». Mais l'idée sous-jacente de considérer que les écosystèmes naturels ou semi naturels contribuent au bien-être des Hommes remonte au moins au 19ème siècle avec l'ouvrage de G.P Marsh, *Man and Biosphere*, paru en 1864 (cité par Mooney and Ehrlich, (1997)). Le concept de services écosystémiques a joué un rôle central dans la représentation des relations société-nature à la suite de deux grandes expertises internationales : le « Millenium Ecosystems Assessment » (MEA, 2001-2005) et « The Economics of Ecosystems and Biodiversity » (TEEB, 2007-2010). Les approches récentes des services écosystémiques soulignent généralement qu'ils résultent des interactions qui façonnent les milieux et le fonctionnement des écosystèmes (Lepart, 2005). Les services écosystémiques correspondent aux flux de matières, d'énergie et d'informations provenant des stocks de capital naturel qui se combinent avec les services du capital manufacturé et du capital humain pour procurer du bien-être aux humains (Costanza et al., 1997). Alors, ils représentent les avantages que les populations retirent des écosystèmes (Costanza et al., 1997; De Groot et al., 2009).

Dans la littérature, les services écosystémiques sont principalement mis en évidence pour leurs aspects positifs en ignorant le plus souvent les impacts négatifs que certains aspects du fonctionnement des écosystèmes peuvent avoir sur le bien-être humain. Ces « mauvais »

services écosystémiques sont souvent nommés dis-services écosystémiques. En effet, s'il est admis que depuis toujours les sociétés humaines ont transformé les écosystèmes pour les adapter à leurs besoins en s'efforçant de limiter ou de contrôler les aspects nuisibles liés à leur fonctionnement, peu d'études se sont penchées sur ces dis-services écosystémiques (Zhang et al., 2007; Lyytimäki and Sipilä, 2009; Dunn, 2010; Escobedo et al., 2011).

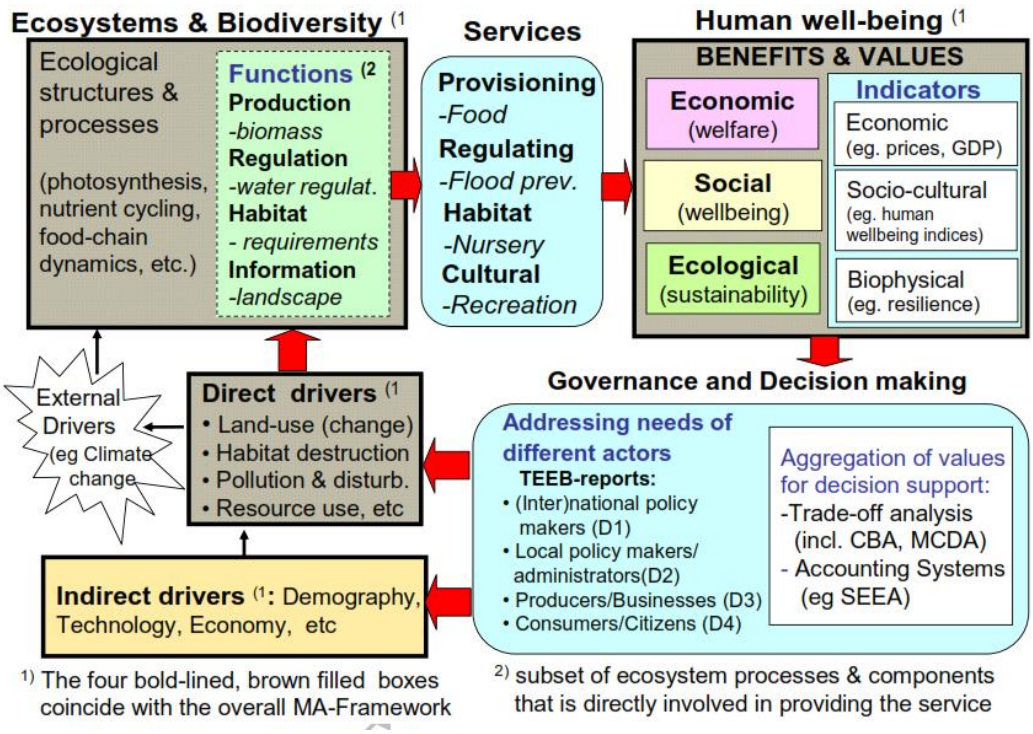
Par ailleurs, ces dis-services écosystémiques ne doivent pas être confondus avec les externalités qui représentent les effets (positifs ou négatifs) de l'activité ou comportement de certains agents sur d'autres qui ne sont pas régulés par des institutions ou les réglementations existantes (parmi lesquels les droits de propriété et les marchés). Les mauvais services écosystémiques représentent l'impact négatif du fonctionnement des écosystèmes sur le bien-être humain. Ils diffèrent donc des externalités en ce que, a priori, ils ne résultent pas d'activités ou de comportements humains. Néanmoins, l'ambiguïté peut apparaître dans des situations où les mauvais services sont aggravés par la mauvaise gestion des écosystèmes par d'autres agents.

Classification des services écosystémiques

Le caractère indispensable des services écosystémiques pour le bien-être humain a été largement documenté (Millennium Ecosystem Assessment, 2005; De Groot et al., 2009). S'il est reconnu que la relation entre la biodiversité et le fonctionnement des écosystèmes ne peut être révélée par les études écologiques qui mettent en avant la structure, le comportement des espèces et des populations en un lieu (Barker et al., 2010), il n'en demeure pas moins que la biodiversité contribue à améliorer la productivité des écosystèmes (Tilman, 1997; Yachi and Loreau, 1999; Hector and Bagchi, 2007). Après une période d'émergence durant laquelle les différents travaux et études proposaient leur propre classification, le Millennium Ecosystem Assessment (2001-2005) a proposé de classer les innombrables services rendus par les écosystèmes en 4 grandes catégories : (i) services d'auto-entretien ; (ii) services de prélèvement ; (iii) services de régulation et (iv) services culturels. L'étude TEEB (2007-2010) en s'appuyant sur celle du MEA, a quant à elle proposé une classification légèrement différente dans le souci de rendre la notion de services compréhensible et d'éviter les problèmes de double compte. Aussi, De Groot et al. (2002) mettent-ils en avant le fait que de par leurs fonctions, les écosystèmes produisent des biens et services dont l'utilisation procure du bien-être à la société sous forme de bénéfices pouvant être évalués (voir figure 1). Par ailleurs, ces fonctions font référence aux différents habitats ou propriétés biologiques et

physiques ou encore aux processus de fonctionnement des écosystèmes (Costanza et al., 1997).

Figure 1: lien entre écosystèmes et bien-être humain



Source : de Groot et al., 2009, p15

Relations environnement et développement

Avec la révolution industrielle, l'Europe occidentale ainsi que les pays anglo-saxons ont connu un cycle de croissance économique accompagné d'un développement industriel, d'une forte urbanisation et d'une pression sur les ressources. Cela a mis à nu la question de savoir si une croissance soutenue est compatible avec la préservation de l'environnement. Les relations « environnement et développement » sont devenus un domaine d'étude important de l'analyse économique. Aujourd'hui et pendant longtemps, les travaux se sont essentiellement organisés autour de deux principaux axes. D'un côté, l'économie des ressources naturelles qui s'intéresse surtout aux ressources épuisables et à la pollution. Les économistes se sont intéressés au lien entre la croissance économique et l'environnement. Pour répondre à cette question, l'économie des ressources offre une variété d'outils parmi lesquels la théorie de la croissance qui permet de retranscrire la relation dynamique entre économie et environnement. Pour bon nombre de chercheurs, La relation entre la croissance économique et

l'environnement reste controversée (Brock and Taylor, 2005; Prieur, 2009). Pour les défenseurs de la Courbe Environnementale de Kuznets qui soutiennent une relation en U renversé entre la croissance économique et la dégradation de l'environnement, il n'existe pas de limite à la croissance (Stern et al., 1996). Seulement, la limite des ressources constitue un frein à la croissance (Van der Ploeg et al., 1987) ; ce qui crée une permanente opposition entre conservation de la nature et croissance économique (Gylfason and Zoega, 2006).

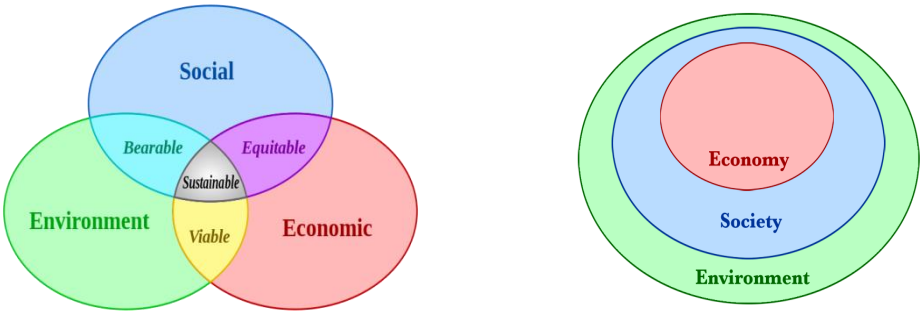
De l'autre côté, l'économie de l'environnement qui s'intéresse à l'évaluation des actifs naturels et la régulation des externalités.

Aujourd'hui, plus que jamais, la perte rapide de la biodiversité est au cœur d'un large débat international. D'une part, le risque d'extinction concerne, à court et moyen termes, plus de la moitié des espèces et, d'autre part, il existe une forte croissance de la demande en biens et services écosystémiques en raison de la croissance démographique et socioéconomique (Millennium Ecosystem Assessment, 2005). Cette réalité conduit donc à une intensification de l'exploitation de la nature pouvant aller, dans certains contextes, au-delà de sa capacité de régénération. Ce qui tend à exacerber le problème. Et cette surexploitation de la nature contribue indéniablement à la perte de la biodiversité, menaçant ainsi la stabilité des écosystèmes (Levrel et al., 2012). Cependant, il faut noter que la contribution des écosystèmes au bien-être humain ne dépend pas seulement de leur abondance ou de leur qualité mais aussi de la capacité des humains, donc de la société, à les utiliser. Autrement dit, le lien entre les écosystèmes et le bien-être dépend des services des écosystèmes potentiellement connus de la société, mais également de sa capacité à les utiliser de façon pertinente ou à s'en passer et à compter sur des moyens alternatifs. Les moyens alternatifs supposent une substituabilité entre le capital naturel et les autres formes de capitaux et à ce niveau, existe un débat entre économistes. Pour les économistes de l'environnement néoclassiques, les rentes provenant des ressources naturelles non renouvelables peuvent être réinvesties dans le capital manufacturé (Hartwick, 1977; Solow, 1986) ; c'est la soutenabilité faible. A côté de cette approche dite de «faible durabilité», existe la soutenabilité forte défendue par l'économie écologique qui soutient que le capital naturel et le capital manufacturé sont dans un rapport de complémentarité plutôt que de de substituabilité (Costanza and Daly, 1992).

La conservation de la nature et sa gestion stratégique ne posent pas seulement un problème d'arbitrage entre l'environnement et le développement. Le problème se présente davantage en termes de capacité des investissements dans la conservation et la restauration durable de la

nature à générer d'importants bénéfices écologiques, sociaux et économiques (De Groot et al., 2002). La durabilité ou soutenabilité renvoie au développement durable qui combine 3 piliers (économique, environnemental, et social) que le rapoort Brundtland (1987) défini comme un objectif de développement compatible avec les besoins des générations futures.

Figure 2: Représentations du développement durable



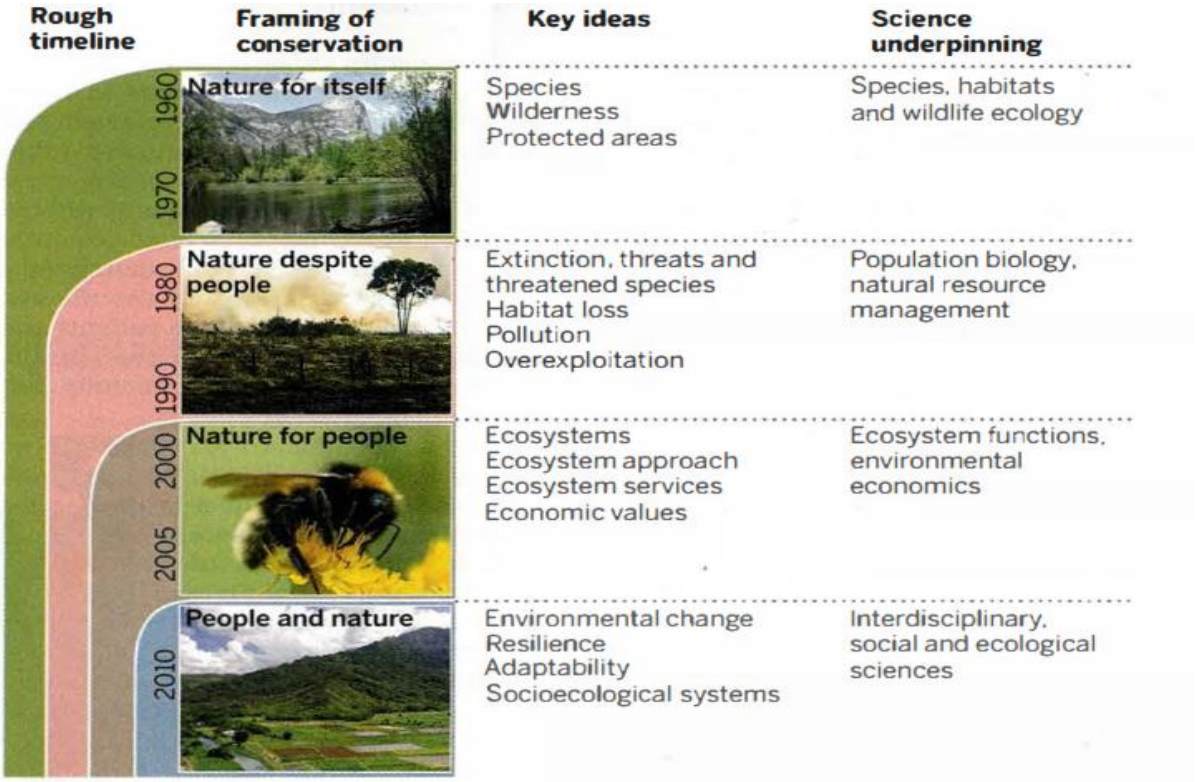
Source : Lozano, 2008, p 1839

Le schéma de gauche, appelé *Diagramme de Venn,* montre l'interdépendance entre l'économie, la société et l'environnement : la soutenabilité se situe à l'intersection de ces composantes. L'environnement est considéré comme un objet économique régi par une configuration marchande. Celui de droite fait plutôt apparaître les liens hiérarchiques entre les différentes composantes tout en mettant en lumière le caractère englobant de l'environnement par rapport aux deux autres composantes. C'est la vision de l'économie écologique qui stipule que du fait de la rareté du capital naturel, l'économie doit s'insérer au sein des régulations écologiques. Ceci étant, la logique économique doit céder le pas à d'autres logiques irréductibles à la première, qui la dépassent (Méral, 2012). En pratique, l'approche hiérarchique sied plus dans une perspective descriptive pendant que l'approche interactive est plus tournée vers une étude des choix. Que l'on se place de l'un ou de l'autre, l'environnement reste omniprésent et très important pour l'économie et la croissance ; ce qui souligne l'importance de le conserver.

Conservation de la nature et de la biodiversité

Le concept de services écosystémiques a été mis en avant pour analyser et communiquer au sujet de notre dépendance à l'égard du fonctionnement des écosystèmes (Costanza et al., 1997; Daily, 1997; De Groot et al., 2002; Millennium Ecosystem Assessment, 2005). Dans la légitimation des politiques de conservation de la biodiversité, deux grands registres de justification sont généralement mobilisés : l'éthique de la responsabilité de l'espèce humaine qui occupe une place prépondérante dans la biosphère et les multiples considérations utilitaristes. Une meilleure appréhension du rôle de la biodiversité est fondamentale pour assurer les moyens de subsistance et le bien-être des populations (Pascual et al., 2010). Mace et al. (2013) identifient quatre phases principales dans les conceptions modernes de la conservation de la nature et de la biodiversité. Dans les années 1960, la nature était protégée pour elle-même. L'accent était mis sur la préservation des habitats naturels et des zones sauvages… Entre 1970 et 1980, l'aggravation de la pression humaine sur la nature et la surexploitation des ressources naturelles ont conduit à une protection de la nature de l'Homme. Puis, à la fin des années 1990, l'évidence de l'omniprésence des pressions humaines a conduit au passage de la protection des espèces vers celle des écosystèmes. Cela s'est fait tout en soulignant l'importance de ces derniers pour le bien-être humain. On parla davantage de la protection de la « nature pour l'Homme ». Enfin, à partir de 2010, on assiste à un rejet de la conception « nature pour l'Homme » vers une relation « nature et Homme » ; ce concept impliquant une utilisation durable des ressources.

Figure 3: Evolution de la relation nature et conservation



Changing views of nature and conservation. Over the past 50 years, the prevailing view of conservation has changed several times, resulting, for example, in a shift in emphasis from species to ecosystems. None of the framings has been eclipsed as new ones have emerged, resulting in multiple framings in use today.

Source : Mace et al., 2013, p1559

De nombreux services écosystémiques sont des produits du fonctionnement naturel des écosystèmes. Ils sont donc disponibles en l'absence de toute intervention humaine et donc d'opération de marché. Ce qui entraine une sous-estimation de leur valeur à la fois par les consommateurs qui ne la voient pas à travers le système de prix et par les décideurs politiques qui ne disposent pas d'indicateurs reflétant l'importance de ces services. Une manière de solutionner ce manque d'information serait d'estimer la valeur des services rendus par les écosystèmes et la biodiversité en termes monétaires et de la rendre explicite dans la prise de décision (Pascual et al., 2010; Salles, 2011).

Evaluation et justification des choix collectifs

La prise de conscience vis-à-vis des écosystèmes et des services qu'ils procurent aux sociétés a pris de l'importance à la fin des années 1990 après la parution de travaux majeurs tels que ceux de Costanza et al. (1997) et Daily (1997). Le principal problème de la gestion des écosystèmes vient de l'information manquante et de la faiblesse des institutions (Gómez-

Baggethun et al., 2010). En effet, il existe peu de marchés pour les services écosystémiques ; ce qui tend à faire négliger leur importance dans la plupart des prises de décisions (Pascual et al., 2010) ; et cela peut compromettre la durabilité de l'homme au sein de la biosphère (Costanza et al., 1997) .

Les services écosystémiques étant les avantages tirés par les populations de la biodiversité et des écosystèmes, les écosystèmes affectés ont par conséquent des répercussions sur le bien être humain. Pour pallier ce problème, il existe des instruments économiques visant à modifier les comportements humains vis-à-vis de l'environnement par un système de prix. Ces incitations financières sont le reflet de ce que nous, en tant que société, sommes prêts à engager pour conserver ces ressources naturelles (Pascual et al., 2010). Dans la littérature, deux types d'instruments sont généralement cités : ceux basés sur des mesures coercitives tels que la réglementation, les taxes et les marchés de permis à polluer ; et ceux basés sur des approches volontaires tels que l'éco-labélisation et la certification. Toutes les politiques environnementales viseraient la conservation de l'environnement et l'internalisation des externalités causées par certains agents à d'autres suite à des dommages faits à l'environnement. Pour cela, elles devraient se baser sur les évaluations de type coûts-avantages et l'évaluation économique offre cette possibilité.

La valeur économique des services écosystèmiques

La valeur de la biodiversité découle à la fois de son rôle dans la fourniture de services et de la demande des populations pour ces services (Barker et al., 2010). En économie, la « valeur » est toujours associée à des compromis, c'est-à-dire qu'une chose n'a de valeur économique que si on est prêt à renoncer à quelque chose pour l'obtenir ou en profiter (De Groot et al., 2009). La notion économique de valeur reflète ainsi à la fois le caractère plus ou moins nécessaire ou désirable des objets, mais également la difficulté et le coût pour les obtenir (on retrouve ici les notions d'utilité, de rareté donc de substituabilité). Donner de la valeur à la biodiversité reviendrait à la considérer comme un bien. Comme le précise Salles (2011), la biodiversité est non seulement un bien mais surtout un bien rare pour deux raisons. La première raison est qu'elle a une valeur pour la société et que sa perte entraine une baisse d'utilité, donc du bien-être. La seconde est que les choix de la société ont des conséquences parfois irréversibles sur elle.

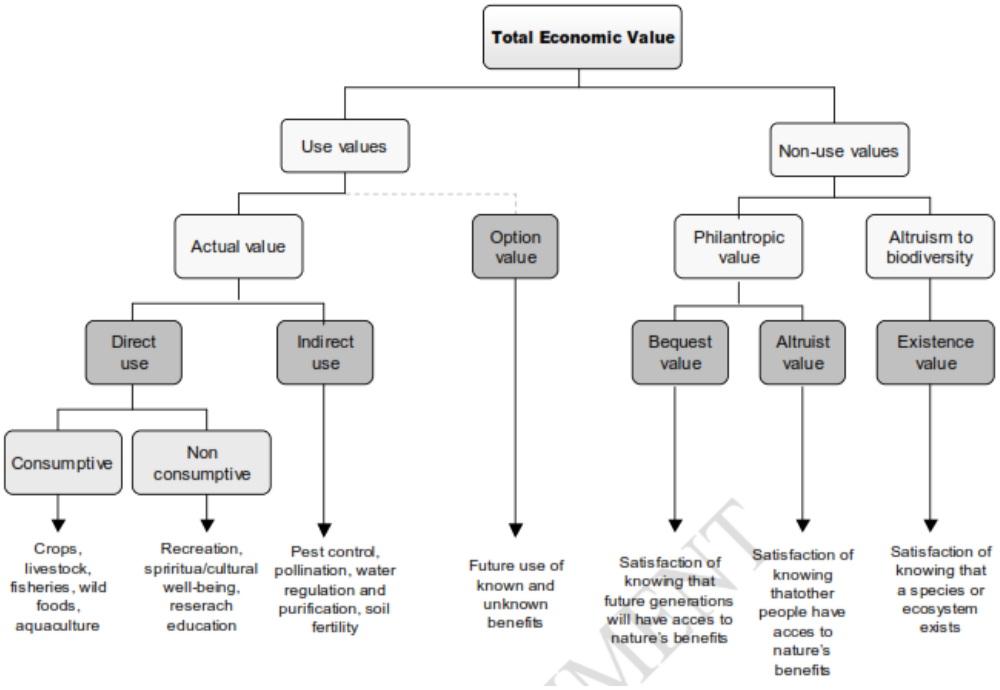
Les relations entre nature et société peuvent être vues sous différents angles qui peuvent être regroupés sous deux grands types de valeurs. D'une part les valeurs instrumentales qui

traduisent le fait que les écosystèmes sont sources de services importants pour le bien-être de la société et de l'autre, les valeurs intrinsèques qui reflètent la reconnaissance que la nature à une valeur en soi indépendamment des intérêts humains.

L'évaluation telle qu'elle est pratiquée actuellement se base davantage sur les préférences individuelles. Pour Justus et al. (2009), l'approche par la valeur intrinsèque n'a cependant pas atteint un niveau d'élaboration permettant une articulation de l'ensemble des étapes passant d'une théorie de justification des choix aux instruments d'analyse. L'approche utilitariste n'implique pas la marchandisation et les grandeurs qui entrent en jeu dans l'évaluation (utilité, bien-être et couts d'opportunité) sont généralement mesurées en termes relatifs (Pascual et al., 2010) ; la valeur mesurée est par conséquent liée à l'utilité marginale de l'actif naturel. Cette utilité marginale peut être approchée par les variations de surplus qui sont estimées à partir des consentements à payer ou à recevoir exprimés en monnaie dont la signification pour les acteurs est facilement perceptible.

Depuis la prise de conscience de l'importance des écosystèmes, les économistes se sont donnés pour objectif de mesurer la valeur économique totale des actifs naturels (VET). Elle intègre différentes formes de valeurs : valeurs d'usage et de non usage qui sont généralement décomposées en plusieurs notions spécifiques de valeur (voir figure 4). La valeur d'usage se réfère aux bénéfices qu'un utilisateur tire directement ou indirectement des écosystèmes. Les usages directs peuvent consommer les ressources (chasse, pêche, cueillette…) ou pas (randonnée, contemplation de la nature). Quant aux usages indirects, ils correspondent aux avantages n'impliquant pas d'interactions directes avec les actifs, tels que la régulation du climat, l'épuration des eaux… La valeur de non usage quant à elle n'implique aucune consommation physique des ressources. Par exemple, la valeur d'existence représente l'intérêt que les agents portent au fait de savoir que la ressource continuera d'exister ; celle du legs représente le consentement à payer pour que les générations futures puissent profiter de la ressource. Quant à la valeur d'option, elle est relative au consentement à payer pour préserver l'option d'avoir la ressource ou des services disponibles à l'avenir quand il y a une incertitude attachée à son utilisation (Dlamini, 2012).

Figure 4: Différentes formes de valeur



Source : Pascual et al. (2010) p14

Pourquoi évaluer ?

La conviction que la valeur économique des écosystèmes constitue un argument fort (bien que non-exclusif) en faveur de leur conservation, a motivé le développement de nombreux travaux d'évaluation économique des services écosystémiques. L'évaluation économique des écosystèmes et de la biodiversité est devenue un champ de recherche très actif depuis le MEA (2001-2005). Partant du principe que l'utilisation de la biodiversité ne se fait pas à coût réel, seuls les instruments économiques et fiscaux paraissent proposer de meilleures mesures de mitigation. Cependant, leur mise en œuvre à travers l'action publique implique d'être en mesure de les justifier socialement, notamment en montrant leur valeur sociale.

L'évaluation environnementale se justifie alors par le besoin de protection de la nature et d'éclairage des décideurs dans le but de satisfaire les besoins humains. Elle reste controversée du fait des considérations morales, éthiques et surtout utilitaristes (la nature n'a de valeur qu'à travers son utilisation). Par ailleurs, l'utilisation des préférences individuelles comme un indicateur pertinent dans l'évaluation environnementale soulève des critiques au sein de la communauté des scientifiques. Des auteurs comme Spash (1997) Norgaard et al.

(1998), Norgaard (2010) et Maris (2014) dénoncent l'obstination des économistes à vouloir mettre de la valeur sur la biodiversité et les services écosystémiques qui selon eux ne résoudrait pas les problèmes précités du fait des liens hiérarchiques entre les composantes « économie-société et environnement ». Pour ces auteurs, la nature étant omniprésente dans la vie de l'homme, lui donner une valeur serait inconvenant. Toutefois, on ne peut pas occulter le fait que l'évaluation puisse servir d'outil d'autoréflexion qui aiderait les acteurs à repenser leurs relations à l'environnement naturel. Elle augmente leurs connaissances sur les conséquences des choix de consommation et oriente le comportement de ceux qui ne sont pas en contact direct avec la nature (Pascual et al., 2010). En effet, même si les bénéfices ne sont pas explicitement évalués, ils le sont implicitement dans la prise de décision (Tyrväinen and Väänänen, 1998). Une municipalité qui alloue des ressources à la gestion d'un espace vert urbain évalue implicitement les bénéfices récréatifs de cet espace du fait qu'il aurait pu servir à d'autres usages et les ressources mobilisées pour cet usage pouvaient être affectées à d'autres fins.

L'évaluation économique des services écosystémiques et de la biodiversité rend explicite les services rendus par ces derniers, et les coûts sociétaux inhérents à l'amortissement ou la dégradation de ces écosystèmes. La quantification et la valorisation des services écosystémiques ne diffèrent pas de celles des biens ou services produits par l'humain. Cependant, elles restent difficiles dans la pratique (Pascual et al., 2010).

L'évaluation se justifie par le besoin de protection des ressources, indispensables au bien-être humain et l'éclairage des décisions qui les concernent. En somme, elle évite le populisme, le paternalisme et les situations dictatoriales (Salles, 2011). D'ailleurs Herendeen (1998) considère que « refuser l'évaluation c'est mettre une barrière entre les chercheurs et les politiques ». De ce fait, les choix collectifs qui s'appuient sur les conclusions d'une évaluation, présentent des garanties plus claires et explicites de leur utilité sociale. Par ailleurs, la notion de valeur qui en résulte, traduit la logique « utilité-rareté » (Langlois, 1997). Ceci conduit à attribuer aux actifs une valeur instrumentale qui reflète leur contribution au bien-être social relativement aux possibilités alternatives (De Groot et al., 2009) ; valeur dont les méthodes d'estimations pourvues de critiques ont été développées par les chercheurs.

Les méthodes d'évaluation

Plusieurs méthodes sont utilisées pour l'estimation des valeurs des services écosystémiques. Ces méthodes peuvent être regroupées en trois principaux groupes suivant le principe

d'analyse de base. Il s'agit des méthodes basées sur : (i) les coûts observables ; (ii) les préférences révélées ; (iii) et les préférences déclarées. Dans chaque catégorie, on retrouve une diversité de techniques adaptées pour chaque valeur et reposant sur une base informationnelle spécifique. Mais seules les méthodes basées sur les préférences déclarées permettent une évaluation de la valeur économique totale (voir tableau 1).

Tableau 1: Relation entre les méthodes d'évaluation et les types de valeur

Approach		Method	Value
Market valuation	Price-based	Market price	Direct and indirect use
	Cost-based	Avoided cost	Direct and indirect use
		Replacement cost	Direct and indirect use
		Restoration cost	Direct and indirect use
	Production-based	Production function approach	Indirect use
		Factor income	Indirect use
Revealed preference		Travel cost method	Direct (indirect) use
		Hedonic pricing	Direct and indirect use
Stated preference		Contingent valuation	Valeur d'usage et de non usage
		Choice modeling/conjoint analysis	
		Contingent ranking	
		Deliberative group valuation	

Source : Pascual et al., 2010, p 24

La présente thèse utilise la méthode des choix discrets : le *choice experiment* pour répondre à ses deux premiers objectifs spécifiques et c'est logiquement que nous présentons la méthode dans la section suivante.

Choice experiment : Etapes, avantages et limites

L'approche en termes de valeur économique totale implique de passer par des méthodes dites de préférences déclarées. L'évaluation contingente qui consiste à demander directement un consentement à payer (CAP) reste la plus utilisée ; mais, depuis deux décennies, elle a fait l'objet de critiques virulentes du fait de nombreux biais rencontrés dans sa conception. Cela a conduit à l'utilisation des méthodes d'évaluation multi-attributs notamment le *choice*

experiment considéré comme *le* Graal des techniques d'évaluation des biens non marchands (Bennett and Adamowicz, 2001). L'objectif de cette méthode est d'évaluer le consentement à payer ou à recevoir d'une population suite à un changement marginal de la quantité ou de la qualité d'un bien. Elle découle de l'évaluation contingente et de l'analyse conjointe mais demande de choisir en fonction des attributs (caractéristiques du bien) au lieu de classer ou d'évaluer (Adamowicz and Boxall, 1998). On demande en général aux répondants de choisir leur option préférée entre le statu quo (état actuel) et un ensemble d'options de biens environnementaux de manière répétée (6 à 8 fois) (Bennett and Adamowicz, 2001). Chaque alternative est décrite suivant des attributs (caractéristiques) déclinés en niveaux (qualitatifs ou quantitatifs) ; un des attributs étant le prix. La méthode vise donc à calculer le taux marginal de substitution (TMS) entre les différents attributs (Hanley et al., 2001). Pour cela, la réalisation du questionnaire, qui nécessite au préalable l'identification des différents attributs et de leurs niveaux susceptibles d'influencer la décision, repose sur plusieurs règles (voir tableau 2).

Tableau 2: Différentes étapes du *choice experiment*

Etapes	Objectifs
Sélection des attributs	Une fois le problème caractérisé et le bien identifié et défini, les attributs pertinents sont choisis. Un prix (monétaire) leur est ajouté afin d'éviter aux agents de construire eux-mêmes leur valeur en déclarant un CAP. Ceci permet également d'estimer des CAP monétaires par le calcul des TMS entre le revenu et les niveaux d'attributs (Freeman, 2003b pp.172-173).
Détermination des niveaux des attributs	Les démarches entreprises à l'étape précédente assurent également une sélection des niveaux appropriés des attributs, c'est-à-dire vraisemblables, réalistes, espacés non linéairement et recoupant les cartes des préférences des agents. Chaque attribut comporte au minimum deux niveaux.
Choix du plan d'expérience	La théorie statistique permet de combiner les différents niveaux d'attributs au sein d'un nombre fini d'alternatives à présenter aux enquêtés. Pour des raisons d'ordre pratique, on utilise souvent des processus factoriels partiels au lieu de processus complets.
Construction des séries de choix	Les alternatives sont regroupées en séries de choix (ou expériences de choix). Ces différents ensembles sont obtenus à partir de logiciels spécifiques. Ils doivent proposer des variations suffisantes de la qualité du service pour permettre l'identification des préférences (Holmes and Adamowicz, 2003) c'est-à-dire que les différences entre les scenarios doivent être suffisamment grandes pour permettre l'estimation statistique de l'impact des variations de qualité (Bennett and Adamowicz, 2001). Toute question d'évaluation met les enquêtés en présence d'un choix entre plusieurs alternatives.
Mesure des préférences et estimation	Les préférences des agents sont mesurées sur la base de leurs choix. La question d'évaluation doit prévenir les risques de comportements stratégiques. Les estimations sont réalisées grâce à la méthode de maximum

de vraisemblance. Les résultats sont ensuite interprétés

Source : (Rulleau, 2008, p:82)

Cette méthode est appréciée du fait qu'elle permet (comme consigné dans le tableau 1) d'évaluer non seulement les valeurs d'usage et de non usage mais en évitant plusieurs biais rencontrés avec l'évaluation contingente. Cependant, comme toutes les méthodes, cette dernière présente aussi des limites. Le tableau 3 présente quelques avantages et limites de cette dernière.

Tableau 3: Avantages et limites du *choice experiment*

Avantages	Limites
• contrôle de l'expérience par le chercheur • détermination des caractéristiques du bien qui influencent les choix (Hanley et al., 1998) • cohérence interne grâce à la répétition (Hanley et al., 1998) • cadre pratique pour l'estimation des compromis entre attributs (Rolfe et al., 2002) • réduction des risques heuristiques (Hanley et al., 2001) • réduction des biais (yea-saying, biais stratégique, biais d'ancrage) • possibilité d'utilisation d'alternatives révélées et d'alternatives hypothétiques • possibilité de choisir le statu quo	• déclaratif et hypothétique • risque de corrélation des réponses pas bien connue (Hanley et al., 1998) • difficultés cognitives (biais d'apprentissage et de fatigue) (Bennett and Adamowicz, 2001)

Source : construction de l'auteur

Objectifs et contribution et de la thèse

Il serait inopportun de parler des objectifs et de la contribution de la thèse, sans préalablement rappeler l'importance des écosystèmes semi naturels tels que les forêts urbaines pour les pays en développement.

Importance des forêts urbaines

Avec l'urbanisation, l'importance des villes dans la conservation de la biodiversité s'est accrue et la question de la survie des espèces dans ces conditions se pose (Kowarik, 2011). Les zones urbaines ne représentent que 2% de la surface terrestre pourtant elles génèrent 78%

des gaz à effets de serre (Dou et al., 2013; Gómez-Baggethun et al., 2013). La concentration de ces impacts anthropiques en milieu urbain entraîne une hausse de la pollution atmosphérique dont la conséquence est la dégradation des conditions de vie. Ce constat a accru l'intérêt pour les forêts dans les centres urbains. En effet, les forêts urbaines sont davantage utilisées comme des parcs dont les biens et services rendus sont essentiels au développement durable des villes (Baur et al., 2013). En plus de leurs buts récréatif et éducatif, les parcs compensent le faible niveau de biodiversité dans les villes (Cornelis and Hermy, 2004). Promouvoir et préserver la biodiversité au sein des espaces verts urbains représentent un moyen de freiner cette perte de biodiversité (Alvey, 2006; Dovonou-Vinagbè and Chouinard, 2009). Traditionnellement, les zones urbaines sont en effet considérées comme des zones ayant une faible diversité biologique (Alvey, 2006). Mais il n'empêche que des zones urbaines et périurbaines peuvent contenir des niveaux élevés de biodiversité (Araújo, 2003). En milieux urbain et périurbain, les actions humaines constituent un facteur de dégradation ou de réduction de la biodiversité.

Pour protéger cette biodiversité, des zones protégées sont créées dans l'objectif de limiter, voire supprimer les mauvaises actions anthropiques sur une zone bien déterminée. Les parcs urbains répondent à cet esprit car ils peuvent être un réservoir d'espèces en danger (Alvey, 2006). De plus, le stress étant très présent en ville, les aspects récréatifs sont parmi les services les plus valorisés des écosystèmes urbains (Kaplan and Kaplan, 1989; Chiesura, 2004). Ainsi les parcs et les forêts urbaines fournissent une large possibilité de loisir tout en augmentant le bien-être. Les forêts urbaines sont d'ailleurs de plus en plus transformées en parcs.

Au-delà du problème de la conciliation entre la conservation de la biodiversité et l'ouverture au public pour des activités récréatives, cette forme d'utilisation des forêts urbaines pourrait être d'une importance stratégique dans la conservation de la biodiversité et la préservation des espèces menacées (Alvey, 2006; Dovonou-Vinagbè and Chouinard, 2009).

Contribution de la thèse

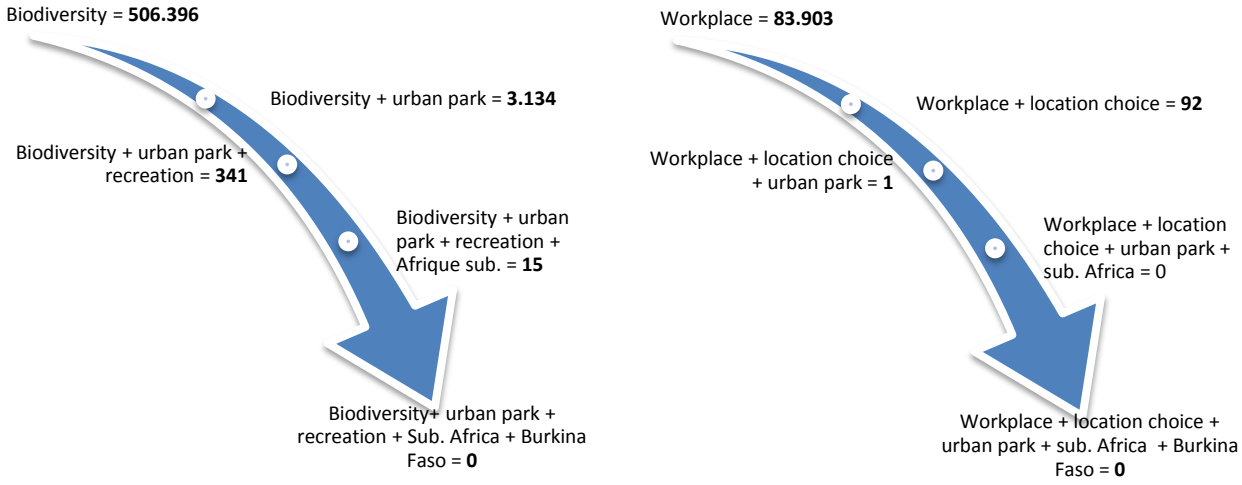
Tous ces développements montrent que la rencontre entre les sciences économiques et l'environnement soulève une série d'interrogations ayant nourri l'intérêt que les chercheurs de divers domaines ont accordé aux écosystèmes. Ces questions ont surtout concerné l'évaluation des services liés aux écosystèmes devenues aujourd'hui un questionnement à part entière pour les économistes (les services culturels tels que la récréation, la pollinisation, la

régulation des flux de l'eau…). Ces travaux ont été motivés par la recherche d'arguments en faveur de politiques de conservation de la nature. Aux questionnements ayant conduit à des travaux d'évaluation des services liés aux écosystèmes (tels que les loisirs en plein air, les aménités vertes, biodiversité…), s'ajoutent ceux liés l'intégration des services écosystémiques dans les processus de développement.

L'évaluation de la biodiversité et des écosystèmes dans les pays en développement demeure un domaine d'étude prometteur pour la littérature (Christie et al., 2008). Les régions tropicales pauvres, qui concentrent la majorité de la biodiversité (Christie et al., 2008; Leh et al., 2013) et une forte pression d'origine anthropique (Myers et al., 2000) en raison d'une aspiration au développement et à la réduction de la pauvreté (Sunderlin et al., 2005), méritent un intérêt particulier (Manuela, 2014). Les populations des pays en développement dépendent principalement des services écosystémiques pour leur nourriture et leur santé (De Groot et al., 2009). Si ces dernières années, l'intérêt pour l'environnement a donné lieu à de nombreuses études sur l'évaluation environnementale, celles-ci ont surtout concerné les pays développés sur des enjeux majeurs. Le seul domaine présent dans la littérature concernant les pays en développement est sans doute l'analyse des mécanismes de Réduction des Emissions liées à la Déforestation et la Dégradation des forêts dans les pays en développement (REDD et REDD+). Dans le cadre de cette thèse, nous arrivons à des questions diverses mais précises en lien le parc urbain Bãngr-weoogo, autrefois forêt urbaine, dont les objectifs sont le maintien d'un poumon vert pour la ville ; la conservation de la biodiversité, l'enseignement des sciences naturelles et les loisirs en plein air. **Quelles sont les caractéristiques qui ont le plus d'impact sur le bien être des visiteurs de ce parc? Quelle est l'importance de ce parc pour les habitants de la ville? A une échelle plus globale, quel rôle pourrait jouer la préservation des écosystèmes dans la dynamique économique et quel est l'impact du poids de la nature (rôle joué dans la production) sur cette dynamique?**

Nous avons donc été amenés à faire de l'évaluation dans le but de répondre à nos questions. Une analyse bibliographique sur le *web of science* à l'aide des mots clés en lien avec nos thèmes traités tout au long de cette thèse montre le manque d'études en relation nos questions de recherche, dans les pays en développement. En effet, les graphes suivants montrent que quand on associe les mots clé à l'Afrique au sud du Sahara, le nombre d'études décline fortement.

Figure 5: Nombre d'articles en rapport avec les études empiriques sur le WOS



Source : analyses bibliographiques sur le Web Of science menées par l'auteur

La même recherche, avec les mots clés a été effectuée sur la base bibliographique « EconLit » a donné les mêmes résultats. Pourtant, la littérature est foisonnante dans ces domaines dans les pays développés. Ces nombreuses études permettent de nos jours aux scientifiques de ces pays de réaliser des études sur la base de Meta-analyses qui permettent de tirer des conclusions globales sur une question spécifique. Pour les pays en développement, beaucoup reste à faire.

Objectifs et plan de la thèse

La thèse s'articule autour de 3 objectifs spécifiques en lien avec l'importance d'une forêt urbaine dans les pays en développement.

- ✓ Premièrement, elle vise à mieux appréhender l'importance des services écosystémiques dans le contexte particulier d'un parc urbain. Le but est donc d'identifier les caractéristiques de ce milieu semi-naturel qui ont le plus d'intérêt pour les visiteurs de cet espace ;
- ✓ deuxièmement, elle vise à comprendre l'importance de cet espace semi-naturel dans la vie des citadins précisément dans leur choix de localisation résidentiel ;

✓ pour finir, elle vise à comprendre en quoi la préservation d'écosystèmes pourrait être déterminante dans la dynamique de croissance économique à une échelle globale.

Ces objectifs constituent la charnière de la présente thèse et l'organise autour des 3 prochains chapitres (sous format article) qui la compose. Dans le chapitre 2, nous nous interrogeons sur la valeur accordée à la biodiversité et aux loisirs en plein air (espaces aménagés et restrictions) au sein d'un parc urbain : Bãngr-weoogo de Ouagadougou (Burkina Faso). Cette étude vise à comprendre le compromis entre la biodiversité et la recréation au sein du parc, en utilisant une méthode de choix discrets : le *choice experiment* présenté plus haut. Elle se base donc sur les préférences des visiteurs du Parc. Le chapitre 3 se propose d'analyser empiriquement l'importance des aménités vertes dans le choix résidentiel des habitants de la ville de Ouagadougou. L'étude met en avant les caractéristiques qui expliquent le choix de localisation des habitants et les interactions entre elles. Elle a pour but d'éclairer les décideurs politiques, particulièrement les représentants de communes de la ville de Ouagadougou dans les politiques d'aménagement de la ville en essayant de comprendre le compromis entre la distance du domicile au parc urbain et la distance du domicile au lieu de travail ainsi que d'autres attributs du choix de localisation. Le quatrième chapitre pose la question du rôle des écosystèmes dans la dynamique de croissance dans un modèle de contrôle optimale. L'idée est d'étudier le rôle des services écosystémiques quand ils jouent le rôle de facteurs de production non consommés, combinés avec d'autres facteurs (comme l'agriculture ou les usages récréatifs) dans la dynamique économique. Pour ce chapitre, des choix forts ont été faits :

- un modèle général qui pose une question de façon abstraite. Il va s'en dire que la résolution du modèle n'est pas suivie d'une étude empirique ;
- nous considérons la nature non pas comme une ressource mais un capital qui ne s'auto-régénère pas;
- la nature est sources de dis-services.

Enfin, le dernier chapitre présente quelques limites de la thèse ainsi que les perspectives d'amélioration.

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Chapter I: Introduction

Interest in ecosystem services assessment has been growing in both scientific and policy perspectives. The Millenium Ecosystem Assessment (2001-2005) clarified the diversity of benefits that humans derive from ecosystems, and promoted the term ‘ecosystem services’ to describe them. Recent emphasis has been put on regional and national ecosystem assessments and the development of economic valuation methods and tools to support decision making.

As a first step, it is important to define the concepts and notions mobilized throughout this thesis in order to clarify its scope and the main issues it will address. The most recent studies on this topic will be presented as well as the link between the different parts of the thesis. As Ecosystem Services (ES) are the cornerstone of this thesis, they are subject to a particular development.

The paternity of the term “ecosystem services” is often attributed to Ehrlich and Ehrlich (1982). However, the underlying idea that is to consider that natural or semi-natural ecosystems contribute to the well-being of humans dates back to the 19th century with the work of GP Marsh, “Man and Biosphere”, published in 1864 (cited by Mooney et Ehrlich, (1997)). The concept of ecosystem services has played a central role in the representation of the link between nature and society in the aftermath of two major international expertises: the Millennium Ecosystems Assessment (MEA, 2001-2005) and The Economics of Ecosystems and Biodiversity (TEEB, 2007-2010). Recent approaches of ecosystem services generally highlight that they result from the interactions which form the physical environment and the ecosystem functioning (Lepart, 2005). Ecosystem services correspond to the flow of matter, energy and information from natural capital stocks, which combined with manufactured and human capital, provide welfare to humans (Costanza et al., 1997). So they are the benefits that people obtain from ecosystems (Costanza et al., 1997; De Groot et al., 2009).

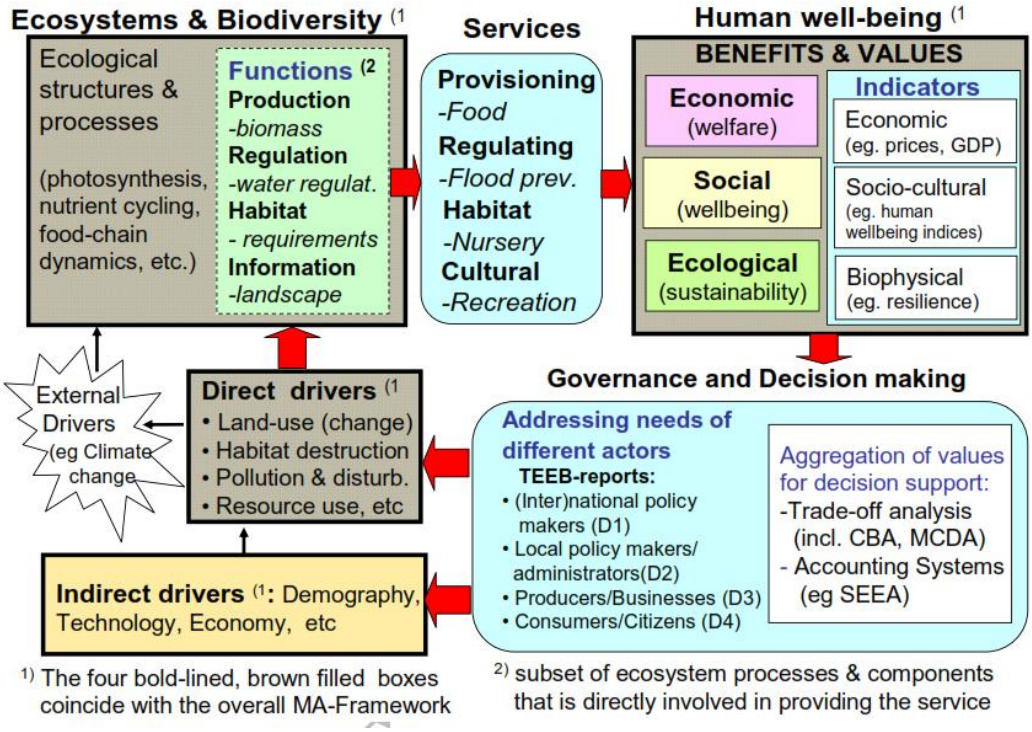
In the literature, ecosystem services are mainly considered for their positive aspects, ignoring the negative impacts that some aspects of ecosystem functioning may have on human well-being. These "bad" ecosystem services are often named ecosystem disservices. Indeed, it is recognized that human societies have always changed ecosystems to adapt them to their needs by attempting to limit or control their harmful aspects. Few studies have examined these ecosystem disservices (Zhang et al., 2007; Lyytimäki and Sipilä, 2009; Dunn, 2010; Escobedo

et al., 2011). Moreover, ecosystem disservices should not be confused with externalities that represent the effects (positive or negative) of the activity or behavior of some agents on others, without regulation by existing institutions (including property rights and markets). Ecosystem disservices represent the negative impact of ecosystems functioning on human welfare. They therefore differ from externalities in that, a priori, they are not the result of human activities or behavior. Nevertheless, the ambiguity may appear in situations where the quality of services is affected by the poor management of ecosystems by other agents.

Classification of ecosystem services

The importance of ecosystem services for human welfare has been widely documented (Millennium Ecosystem Assessment, 2005; De Groot et al., 2009). It is recognized that the relationship between biodiversity and ecosystem functioning cannot be revealed by ecological studies that highlight the structure, the behavior of species and populations (Barker et al., 2010). But, the fact remains that biodiversity helps improving the productivity of ecosystems (Tilman, 1997; Yachi and Loreau, 1999; Hector and Bagchi, 2007). After an emergence period during which the different studies offered their own classification, the Millennium Ecosystem Assessment (2001-2005) proposed to classify the numerous services rendered by ecosystems in 4 major categories: (i) supporting services; (ii) provisioning services; (iii) regulating services and (iv) cultural services. TEEB (2007-2010) has meanwhile proposed a slightly different classification, based on the one of the MEA, in order to make the concept understandable and avoid problems of double counting. De Groot et al. (2002) emphasize that from their functions, ecosystems produce goods and services that provide welfare to society in the form of evaluable benefits (see Figure 1). Furthermore, these functions refer to different habitats or biological and physical properties or the ecosystem processes (Costanza et al., 1997).

Figure 1: conceptual framework for linking ecosystems and human well-being



Source : de Groot et al., 2009, p15

Relations between environment and development

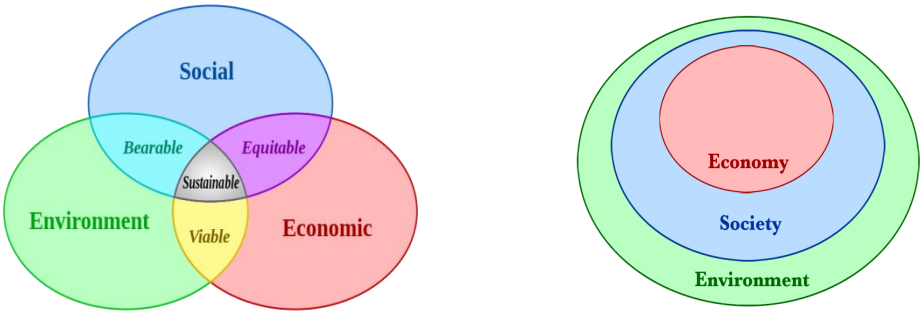
The industrial revolution propelled throughout Western Europe and other Anglo-Saxon countries in a cycle of economic growth accompanied by industrial development, a strong urbanization and pressure on resources. This has exposed the question of whether economic growth is compatible with environmental preservation. The link between "environment and development" has become an important field of study of the economic analysis. Research efforts have so far mainly been organized along two main axes. On the one hand, the economy of natural resources is particularly interested in renewable resources and pollution. Economists have studied the link between economic growth and environment. Resource economics provides a variety of tools including growth theory that allows studying the dynamic relation between economy and environment. For many researchers, the relation between economic growth and environment remains controversial (Brock and Taylor, 2005; Prieur, 2009). For advocates of the Environmental Kuznets Curve which support a reversed U-shaped relation between economic growth and environmental degradation, there is no limit to growth (Stern et al., 1996). Nevertheless, the limits of resources hinder growth (Van der Ploeg et al., 1987). This creates a permanent opposition between nature conservation and economic growth (Gylfason and Zoega, 2006).

On the other hand, Environmental economics focuses on the evaluation of natural assets and the regulation of externalities.

Today, more than ever, the rapid loss of biodiversity is at the heart of a broad international debate. First, the risk of extinction concerns in the short run, more than half of the species and secondly, there is a strong growth in demand for ecosystem goods and services because of socioeconomic reasons and population growth (Millennium Ecosystem Assessment, 2005). This reality thus leads up to an intensification of the exploitation of nature, in some contexts, beyond its regenerative capacity; which tends to exacerbate the problem. This overexploitation of nature contributes undeniably to a loss of biodiversity, threatening the stability of ecosystems (Levrel et al., 2012). However, it should be noted that the contribution of ecosystems to human welfare depends not only on their abundance or quality but also the ability of humans and of all the society to use them. In other words, the link between ecosystems and human welfare depends on the ecosystems services potentially known but also on the society ability to use them appropriately or to do without them and rely on alternative ways. Alternative ways assume substitutability between natural capital and other forms of capital, which raises debate among economists. For neoclassical environmental economists, the rents from non-renewable natural resources can be reinvested in manufactured capital (Hartwick, 1977; Solow, 1986); it is the weak sustainability. On the other side, the strong sustainability is defended by ecological economics that considers that natural and manufactured capitals are in a complementarity relation rather than substitutes (Costanza and Daly, 1992).

Nature conservation and its strategic management do not pose only a problem of arbitration between the Environment and development. The problem comes from the capacity of investments in conservation and sustainable restoration of nature to generate significant ecological, social and economic benefits (De Groot et al., 2002). Sustainability refers to a "development" that combines the three pillars: economic, environmental, and social. Brundtland (1987) defined it as a development objective consistent with the needs of future generations.

Figure 2: Sustainable development representations



Source : Lozano, 2008, p 1839

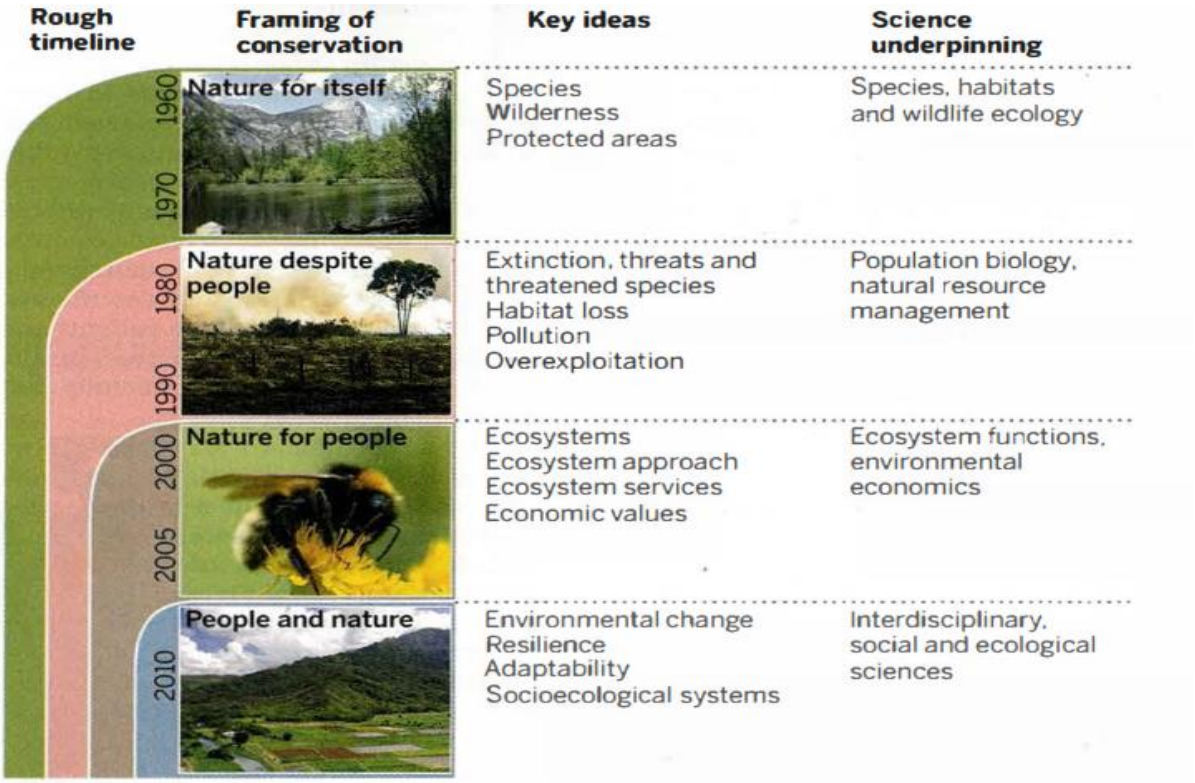
The left diagram, called a Venn's diagram shows the interdependence between economy, society and the environment. Sustainability is at the intersection of these components. The Environment is seen as an economic object governed by a market configuration. The right one rather shows the hierarchical relationship between the different components and emphasize that the Society and the Economy are included in the Environment. It is the vision of ecological economics, which states that due to the scarcity of natural capital, the economy must fit in ecological regulations. That said, the economic logic must give way to other logic, which exceed it (Méral, 2012). In practice, the hierarchical approach is well adapted for descriptive purposes while the interactive approach rather addresses the study of choices. Whatever the approach chosen, the Environment remains omnipresent and important for the Economy and growth and should therefore be conserved.

Nature and biodiversity conservation

The concept of ecosystem services has been put forward to analyze and communicate about our dependence on ecosystem functioning (Costanza et al., 1997; Daily, 1997; De Groot et al., 2002; Millennium Ecosystem Assessment, 2005). Two major justifications are usually mobilized to legitimate biodiversity conservation policies: the ethics of responsibility of humans for other species and multiple utilitarian considerations. A better understanding of the role of biodiversity is fundamental to human livelihood and their well-being (Pascual et al., 2010). Mace et al. (2013) identify four main phases in modern conceptions of nature conservation and biodiversity. In the 1960s, nature was protected for itself. The focus was on the preservation of natural habitats and wild areas. Between 1970 and 1980, the worsening of the human pressure on nature and the overexploitation of natural resources have led to the protection of nature to humans' pressures. Then, in the late 1990s, evidence of the omnipresence of human pressure led to a transition from the concept of "protection of

species" to the "preservation of ecosystems". During the same period, the importance of ecosystems for human welfare was also underlined driving to the protection of "nature for humans". Finally, since 2010, the concept of "nature for human" is replaced by the relation "Nature and Man" that involves the sustainable use of resources.

Figure 3: nature and conservation



Changing views of nature and conservation. Over the past 50 years, the prevailing view of conservation has changed several times, resulting, for example, in a shift in emphasis from species to ecosystems. None of the framings has been eclipsed as new ones have emerged, resulting in multiple framings in use today.

Source : Mace et al., 2013, p1559

Many ecosystem services are outputs of the natural functioning of ecosystems. They exist in the absence of human intervention and thus market. Their value is therefore generally underestimated both by consumers who do not see them through the price system and policy makers who do not have indicators reflecting their importance. One way to compensate this lack of information is to estimate the monetary value of services provided by ecosystems and biodiversity and make it explicit in the decision making (Pascual et al., 2010; Salles, 2011).

Economic valuation and the justification of collective choices

Awareness of the ecosystems and the services they provide to society has gained prominence in the late 1990s after the publication of major research efforts such as those of Costanza et al. (1997) and Daily (1997). The main problem of ecosystem management comes from the lack of information and the weakness of institutions (Gómez-Baggethun et al., 2010). Indeed, there are few markets for ecosystem services. Their importance in most decisions is therefore often overlooked (Pascual et al., 2010); and this can compromise the sustainability of humans in the biosphere (Costanza et al., 1997).

Ecosystem services are the benefits derived by human population from biodiversity and ecosystems; therefore, affected ecosystems have an impact on human welfare. To overcome this problem, some economic instruments try to change human behaviors regarding the environment through a pricing system. These financial incentives are a reflection of what we, as a society, are ready to engage for natural resource conservation (Pascual et al., 2010). In the literature, two types of instruments are usually cited: those based on coercive measures such as regulations, taxes and tradable permits to pollute; and those based on voluntary approaches such as eco-labeling or certification. All environmental policies aim at the environmental preservation and the internalization of externalities caused by some agents to others as a result of environmental damage. These policies should be based on cost-benefit analysis, which require the use of economic valuation.

The economic value of ecosystem services

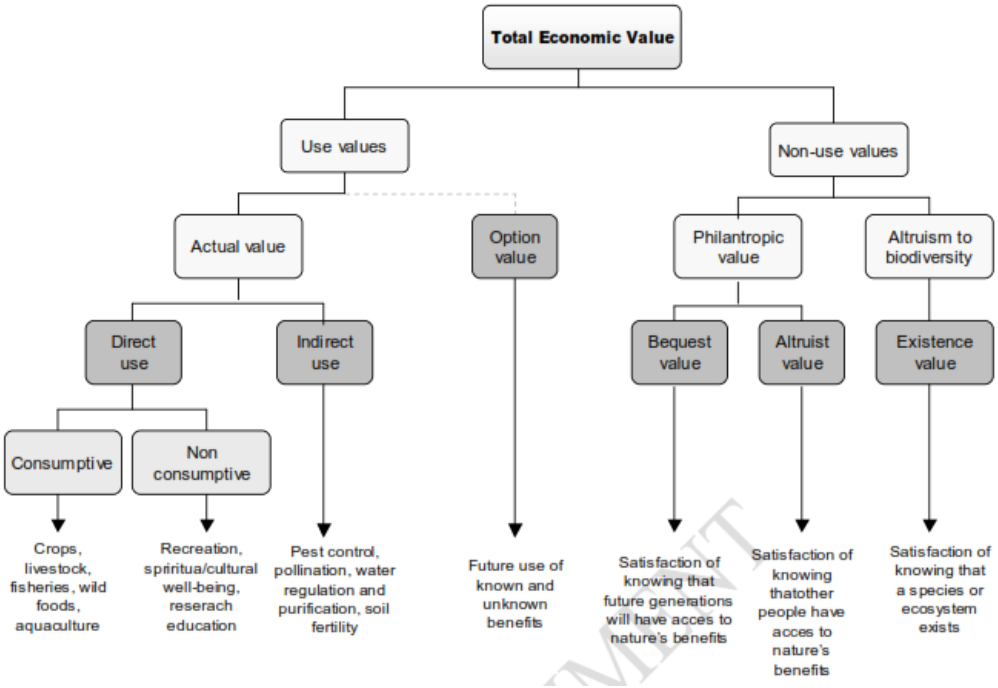
The value of biodiversity comes from both its role in the provision of services and the human demand for these services (Barker et al., 2010). In economic sciences, the "value" is always associated with tradeoffs. For example, a good has an economic value only if one is willing to give up something to get it or enjoy it (De Groot et al., 2009). The economic concept of value reflects more or less the necessity or the desirability of the goods, as well as the difficulty and cost of obtaining them (here we find the notions of utility, scarcity, thus of substitutability). Valuating biodiversity would therefore correspond to consider it as a good. As stated by Salles (2011), biodiversity is not only a good but a rare good for two reasons. The first reason is that it has value for society and its loss leads to decrease welfare. The second is that the choices of society have consequences on it, which are sometimes irreversible.

The link between nature and society can be seen from different angles, which can be grouped under two main types of values: i) the instrumental value, which reflects the fact that ecosystems are sources of important services for the well-being of society and ii) the intrinsic value that reflects the recognition that nature has value regardless of human interests.

Environmental valuation, as practiced nowadays, is based on individual preferences. For Justus et al. (2009), the approach through the intrinsic value has however not reached a level of development that allow an articulation of all the steps from a theory of justification of the choices to analytical instruments. The utilitarian approach does not imply the marketization. Indeed, variables in the evaluation (utility, welfare and opportunity costs) are usually measured in relative terms (Pascual et al., 2010). The measured value is therefore linked to the marginal utility of the natural assets. This marginal utility can be approximated by the variation of surplus, which that can be quite easily estimated in monetary terms by stakeholders using the willingness to pay or receive approach.

Since the acknowledgement of the importance of ecosystems, economists have set the goal of measuring the total economic value of natural assets (TEV). It integrates different forms of values: use and non-use values which are generally broken down into more specific notions of values (see Figure 4). Use value refers to the benefits that a user obtains directly or indirectly from ecosystems. Direct uses may consume resources (hunting, fishing, gathering ...) or not (hiking, contemplation of nature). Indirect use value corresponds to benefits which do not involve direct interaction with assets such as climate regulation; water purification ... The non-use value involves no physical resource consumption. For example, existence value represents the value that people place on the resource so that it continues to exist; bequest value is the willingness to pay to ensure that future generations can enjoy the resource. Option value is relative to the willingness to pay to preserve the option of having the resource or service available in the future when there is uncertainty attached to its use (Dlamini, 2012).

Figure 4: different forms of value



Source : Pascual et al. (2010) p14

Why do we assess the nature?

The conviction that the economic value of ecosystem services is a strong argument (although not exclusively) for their conservation, has motivated the development of numerous works of economic valuation of ecosystem services. Economic valuation of ecosystems and biodiversity has become a very active field of research since the MEA (2001-2005). Assuming that the use of biodiversity is not done at real cost, only economic and fiscal instruments appear to offer better mitigation measures. However, their implementation through public action involves being able to justify it socially, particularly by showing their social value.

Environmental valuation is therefore justified by the need to protect nature and to inform decision makers, with the ultimate goal to satisfy human needs. It remains controversial because of moral, ethical and above all utilitarian issues (nature has value only through its use). Furthermore, the use of individual preferences as a relevant indicator in environmental assessments raises criticism in the scientific community. Authors like Spash (1997), Norgaard et al. (1998), Norgaard (2010) and Maris (2014) condemn the persistence of economists to put value on biodiversity and ecosystem services. According to them, it would not solve the above problems due to the hierarchical relationships between the components "Society-

Economy and Environment". For these authors, nature is omnipresent in human life, and it would be inappropriate to evaluate it. However, one cannot hide the fact that the assessment can serve as a tool for self-reflection that would help the actors to rethink their relationship to the natural environment. It increases their knowledge about the consequences of consumption choices and guides the behavior of those who are not in direct contact with nature (Pascual et al., 2010). Even if the benefits are not explicitly assessed, they are implicit in the decision making (Tyrväinen and Väänänen, 1998). A municipality that allocates resources to the management of urban green space implicitly evaluates the recreational benefits of this space because it could have been used for other purposes and the resources mobilized for this purpose could be assigned to others.

The economic valuation of ecosystem services and biodiversity makes explicit the services rendered by them, and societal costs of depreciation or degradation of these ecosystems. Quantification and valuation of ecosystem services do not differ from those of goods or services produced by humans. However, it remains difficult to implement in practice (Pascual et al., 2010).

Environmental valuation is justified by the need to protect resources, which are essential to human well-being and provide information for decisions that affect them. In short, it avoids populism, paternalism and dictatorial situations (Salles, 2011). Besides, Herendeen (1998) considers that to "refuse the evaluation is to put a barrier between researchers and policy". Therefore, collective choices that are based on an evaluation, present more clear and explicit guarantees of their social utility. Furthermore, the resulting notion of value reflects the logic "utility-scarcity" (Langlois, 1997). This leads to assign to the assets an instrumental value that reflects their contribution to the well-being as compared to alternative social possibilities (De Groot et al., 2009). Many types of estimation methods have been developed by researchers.

Evaluation methods

Several methods are used to estimate the value of ecosystem services. These methods can be divided into three main groups according to the principle of their basic analysis: methods based on (i) the observable cost; (ii) the revealed preferences; (iii) and stated preferences. In each category, there are a variety of appropriate techniques for each value. But only the methods based on stated preferences allow an assessment of the total economic value (see Table 1)

Table 1: Relation between assessment methods and the types of value

Approach		Method	Value
Market valuation	Price-based	Market price	Direct and indirect use
	Cost-based	Avoided cost	Direct and indirect use
		Replacement cost	Direct and indirect use
		Restoration cost	Direct and indirect use
	Production-based	Production function approach	Indirect use
		Factor income	Indirect use
Revealed preference		Travel cost method	Direct (indirect) use
		Hedonic pricing	Direct and indirect use
Stated preference		Contingent valuation	Use and non-use
		Choice modeling/conjoint analysis	Use and non-use
		Contingent ranking	Use and non-use
		Deliberative group valuation	Use and non-use

Source : Pascual et al., 2010, p 24

This thesis uses discrete choices method, the choice experiment, to address its two first specific objectives. We therefore present the logic of the choice experiment methodology in the following section.

Choice experiment: Phases, advantages and limitations

Estimating the total economic value of an ecosystem implies the use of stated preferences methods. Contingent evaluation, which consists in directly requesting people their willingness to pay (WTP), remains the most widely used. But since two decades, it has been the subject of harsh criticism due to numerous biases encountered in its design. This has led to the use of multi-attributes evaluation methods especially the choice experiment. It is considered as the Grail of non-market goods evaluation methods (Bennett and Adamowicz, 2001). The goal of this method is to assess population's willingness to pay or receive following a marginal change in the quantity or quality of the goods. It stems from contingent evaluation and conjoint analysis but requests people to choose a good based on its attributes (or characteristics) instead of classifying or evaluating it (Adamowicz and Boxall, 1998). It generally requires respondents to choose repeatedly (6-8 times) their preferred option from the status quo (current state) and a set of environmental goods options (Bennett and

Adamowicz, 2001). Each alternative is described by attributes (characteristics) broken down into levels (qualitative or quantitative); one of the attributes being the price. The method aims to calculate the marginal rate of substitution (TMS) between the different attributes (Hanley et al., 2001). Thereby, the questionnaire realization which requires the identification of the various attributes and their levels influencing the decision, rests on several rules (see table 2).

Table 2: Choice experiment's steps

Steps	Objectives
Attributes Selection	Once the problem characterized, well identified and defined, the relevant attributes are selected. A price (monetary) is added to prevent agents to build their own value by declaring a WTP. This also allows an estimation of the monetary WTP by calculating MRS between income and levels of attributes (Freeman, 2003b pp.172-173).
Attributes levels Determination	The previous step also provide a selection of the appropriate attributes levels, that is to say plausible, realistic, nonlinearly spaced and intersecting agent's cards preferences. Each attribute has at least two levels.
Experimental design choice	Statistical theory combines different levels of attributes within a finite number of alternatives to be presented to respondents. For practical reasons, partial factorial process is often used instead of complete process.
Sets of choice construction	Options are grouped into choices' sets. These different sets are obtained from specific software. They must offer sufficient variations in good quality to enable identification of preferences (Holmes and Adamowicz, 2003); that is to say that the differences between the scenarios must be large enough to allow statistical estimate of the impact of changes in quality (Bennett and Adamowicz, 2001). Any evaluation question puts respondents in the presence of a choice between several alternatives.
Preference and estimation measurement	Agents' preferences are measured based on their choices. The evaluation question must prevent the risk of strategic behavior. The estimates are made using the maximum likelihood method. The results are then interpreted

Source : (Rulleau, 2008, p:82)

This method is widespread because it allows (as noted in Table 1) to assess use and non-use values while avoiding several biases encountered with contingent evaluation. However, like

all methods, it also has limitations. The table below shows some of its advantages and limitations.

Table 3: Benefits and limitations of the choice experiment

Advantages	Limitations
• The researcher controls the experience • Determination of the characteristics of the goods that influence choices (Hanley et al., 1998) • Internal consistency validated through repetition (Hanley et al., 1998) • Practical framework for the estimation of tradeoffs between attributes (Rolfe et al., 2002) • Reduced heuristics risk (Hanley et al., 2001) • Bias reduction (yea-Saying, strategic bias, bias anchor) • Possibility to use proven and hypothetical alternatives • Possibility to choose the status quo option	• Declarative and hypothetical • Correlation risk (Hanley et al., 1998) • Cognitive difficulties (learning bias and fatigue) (Bennett and Adamowicz, 2001)

Conducted by the author

Objectives and contribution of the thesis

It would be inappropriate to talk about the goals and the contribution of the thesis, without reiterate the importance of semi-natural ecosystems such as urban forests in developing countries.

Importance of urban forests

With urbanization, the importance of cities in the conservation of biodiversity has increased and the question of species survival in these conditions arises (Kowarik, 2011). Urban areas account for only 2% of the Earth's surface yet they generate 78% of greenhouse gas (Dou et al., 2013; Gómez-Baggethun et al., 2013). The concentration of these anthropogenic impacts in urban areas leads to increased air pollution whose consequence is the degradation of life conditions. This observation has increased the interest for forests in the urban centers. Indeed, urban forests are usually used like parks that provide goods and services that are essential for the sustainable development of cities (Baur et al., 2013). In addition to their recreational and

educational purposes, parks can offset the low level of biodiversity in cities (Cornelis and Hermy, 2004). Promoting and preserving biodiversity in urban parks is therefore a way to stop this loss of biodiversity (Alvey, 2006; Dovonou-Vinagbè and Chouinard, 2009). Traditionally, urban areas are indeed considered as areas of low biodiversity (Alvey, 2006). But the fact remains that urban and suburban areas may contain high levels of biodiversity (Araújo, 2003). In urban and suburban environments, human actions are factors of biodiversity degradation or reduction.

To protect biodiversity, protected areas are created with the aim to limit or even eliminate the harmful human's actions on a well-defined area. Urban parks follow the same goal because they can be a reservoir of endangered species (Alvey, 2006). In addition, due to the prevalence of stress in cities; recreational aspects are among the most valued of urban ecosystems services (Kaplan and Kaplan, 1989; Chiesura, 2004). Parks and urban forests therefore provide a wide possibility of leisure while increasing welfare. Urban forests are also increasingly turned into parks.

Beyond the problem of reconciling biodiversity conservation and access of the public for recreational activities, this form of use of urban forests could have a strategic importance in the conservation of biodiversity and the preservation of endangered species (Alvey, 2006; Dovonou-Vinagbè and Chouinard, 2009).

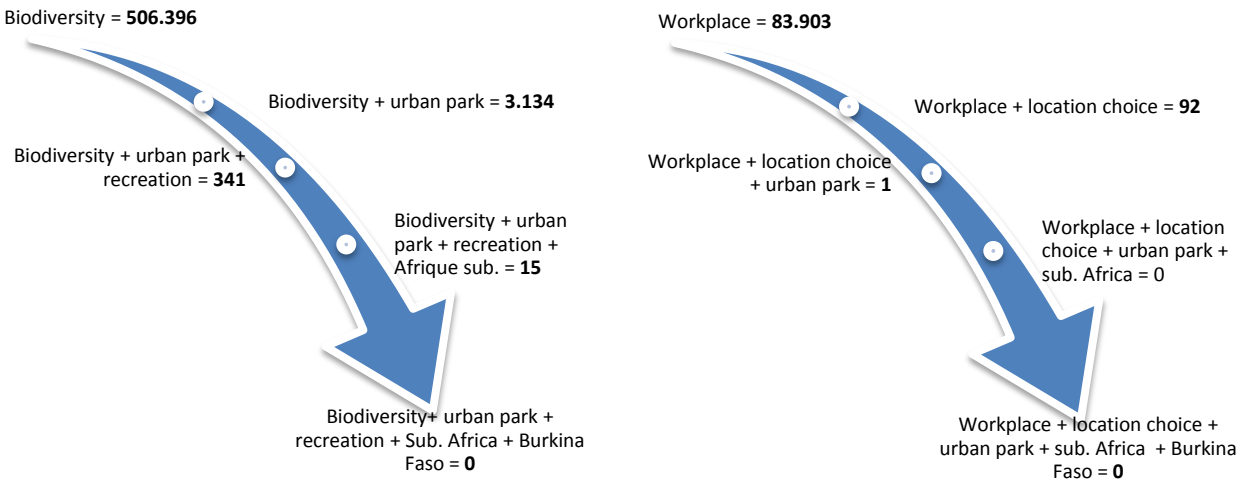
Thesis contribution

All these developments show that the intersection between Economics and Environment sciences raises a series of questions that have nourished the interest of researchers from various fields on ecosystems. These questions concern mainly the assessment of ecosystem services which is nowadays a full-fledged field for economists (cultural services such as recreation, pollination, regulation of water flows ...). These works was motivated by the research for arguments in favor of nature conservation policies. To the questions that led to the assessment ecosystem services' (such as outdoor recreation, green amenities, biodiversity...) are added those related to the integration of ecosystem services into development process.

The assessment of biodiversity and ecosystem services in developing countries remains a promising field of study (Christie et al., 2008). Poor tropical areas that concentrate the majority of biodiversity (Christie et al., 2008; Leh et al., 2013) and strong anthropogenic

pressures (Myers et al., 2000) due to development and poverty reduction aspiration (Sunderlin et al., 2005), deserve a special interest (Manuela, 2014). Developing countries populations mainly depend for their food and their health on ecosystem services (De Groot et al., 2009). If in recent years, interest in the Environment has raised several studies based on environmental assessments; it concerned mainly developed countries and major issues. The only area of research on developing countries is undoubtedly the analysis of mechanisms of Emissions from Deforestation Reduction and Forest Degradation in Developing Countries (REDD and REDD +). As part of this thesis, we raised up different and specific questions related urban park: Bãngr-weoogo of Ouagadougou (Burkina Faso). This park has many objectives such as maintaining a green lung for the city; the biodiversity conservation, the teaching of natural sciences and outdoor recreation. **What are the characteristics of Bãngr-weoogo that have the greatest impact on the visitors' welfare? What is the importance of Bãngr-weoogo for the inhabitants of Ouagadougou city? Globally, what is the role of ecosystems preservation in economic dynamics and what is the impact of the weight of nature (role in the production) in this dynamic?** We have been led to make an evaluation in order to answer the questions. A literature review on the Web of Science using keywords related to our themes shows a lack of studies in relation to our research questions in developing countries. Indeed, the following graphs show that when one combines the key words to Africa south of the Sahara, the number of studies declines sharply.

Figure 5: Number of articles related to empirical studies on WOS



Source: Literature reviews on Web of Science conducted by the author

The same search with our keywords was performed on the bibliographic database "EconLit" and gave the same results. However, literature is abundant in developed countries. These numerous studies allow scientists nowadays to conduct studies on the basis of Meta-analyzes that allow drawing global conclusions on a specific issue. For developing countries, much remains to be done.

Thesis Objectives

The thesis addresses three specific objectives (under article format) related to the importance of urban forests in developing countries.

- The first objective is to assess ecosystem services in the particular context of an urban park. The goal is to identify the characteristics of the semi-natural environment that have the most interest for the parks' visitors;
- the second objective is to understand the importance of semi-natural spaces in the lives of urban dwellers; specifically in their residential location choice;
- finally, the third objective is to apprehend how the preservation of ecosystems could be decisive in the economic growth on a global scale dynamic.

These objectives form the basis of this thesis and are organized around the next three chapters.

In Chapter 2, we question the biodiversity and outdoor recreation values (relaxing areas and recreational restrictions) of an urban park: Bãngr-weoogo-Ouagadougou (Burkina Faso). This study aims at understanding the trade-off between biodiversity and recreation in this park, using the choice experiment method presented above. It is therefore based on the visitors' preferences about the park. Chapter 3 aims to empirically analyze the importance of green amenities in the residential location choice of the inhabitants of the city of Ouagadougou. The study highlights the characteristics that explain the location choice of the people and the interactions between them. It aims to inform policy makers, particularly the representatives of the city municipalities of Ouagadougou, about the inhabitants' tradeoff between their distance from home to the city park and the distance from home to their workplace and other attributes of their residential location choice. The ultimate goal is to contribute to the improvement of urbanization policies. The fourth chapter questions the role of interactions between ecosystem services when combine with other production factors in economic dynamic and the role of natural capital weight in this dynamic. For this chapter, strong assumptions were made:

- A general theoretical model without an empirical study;
- We consider nature not as a resource but a capital which does not naturally regenerate;
- Nature is the source of dis-services.

The last chapter concludes the thesis and presents some limits and perspectives.

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Chapter II: Tradeoffs between conservation and recreational aspects in urban parks in developing countries: evaluating the Bãngr-Weoogo Park in Ouagadougou

Tradeoffs between conservation and recreational aspects in urban parks in developing countries: evaluating the Bãngr-Weoogo Park in Ouagadougou

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Abstract

The recognition of recreational and conservation benefits of protected areas provides a usable economic rationale for their management. We value the Bãngr-weoogo urban park in Ouagadoudou (Burkina Faso) with respect to ecological and recreational aspects. The paper aims to investigate whether visitors' preferences for recreation and conservation, which often appear as competing objectives, can be reconciled by identifying managements tradeoffs in the different features of the park. We used a choice experiment based on random sampling and face to face interviews with 475 respondents on site. The results show that the current situation of the park is preferred to all the proposed alternatives. Increasing the level of biodiversity appears as the measure most likely to improve the well-being of the visitors. More unexpectedly, the reduction of restrictions on recreational activities tends to reduce their well-being.

Highlights

- We study trade-offs between biodiversity conservation and recreational uses using choice experiment; this is the first study applied to urban forest in developing countries.
- A first interesting result is that increase of biodiversity level clearly improves visitor's welfare
- Visitors really appears sensitive the preserving the feature of the Park, since alleviating recreational restrictions tends to reduce their welfare

Key words: biodiversity management, choice experiment, developing country, recreation restrictions, urban forest

JEL codes: Q26. Q51. Q57

1. Introduction

Recreation is one of the most extensively studied among the many services that people obtain from ecosystems. This can be explained by the fact that recreation is a service well identified by users and for which they can easily be surveyed and express meaningful preferences. Urban and sub-urban forests are increasingly involved in recreational activities (Cole, 1996) and the type of layouts affects probably visitors' preferences for these recreation areas (Tyrväinen et al., 2003). On the one hand, layouts mix intensive use of forests generating unfavorable habitats for some species. On the other hand, there is a strong demand for preserved areas for conservation reasons (Tyrväinen et al., 2003). A better knowledge of users' preferences is necessary to design and provide adequate management solutions (Horne et al., 2005).

Outdoor recreation is considered the main pressure on biodiversity in protected areas (Cole and Landres, 1996) and the main factor threatening species. Outdoor recreation and biodiversity conservation thus appear as competing goals, often pursued by distinct actors. Moreover, in an economic perspective, outdoor recreation is essentially a private good whereas biodiversity conservation is a public good. But the question addressed here relates to how to integrate these two objectives and with what priorities and pattern in the management of an urban park.

The management of urban parks has been shown to be of real importance for the sustainability of large cities (Chiesura, 2004; Brander and Koetse, 2011). In fact, the presence of natural assets (parks and forests) and their components (water and trees) in an urban environment contributes to improving life quality and it is widely recognized that urban parks and green spaces have strategic importance in the life of the inhabitants of large cities (Chiesura, 2004). The issue is crucial for expanding cities whose population increases at high rates as it is the case in developing countries.

In this paper, we enlighten several tradeoffs related to a park in the urban area of Ouagadougou, the capital-city of Burkina Faso: the urban Park Bãngr-weoogo. This old protected forest from the former "Mossi" kingdom (the largest ethnic group), confirmed by the colonial administration, was recently reassigned to the city government that transformed it into an urban park, opened to the public for recreation purposes. The park is facing a rapidly growing frequentation: the number of visits rose from some 30,000 in 2002 to over than 300,000 in 2013. A stronger protection of existing ecosystems and species, and an improvement of recreation facilities are among possible options. But it is unclear to know

which one will have the most beneficial impact on population welfare and what the most preferred management pattern for the park is.

We address these tradeoffs by evaluating changes in visitors' well-being, using a choice experiment. We test for a series of improvements in the park's recreational facilities, in the line of Christie et al., (2007), and for operational management attributes (such as recreational restrictions), like in Juutinen et al. (2011). The originality of our contribution is at least twofold. First, these options are analyzed in a developing country where environmental issues are often viewed as a low priority (Martinez-Alier, 2003). Second, they concern an urban park (the first case in the literature to our knowledge), with a strong historical background on conservation.

The choice experiment approach allows users of the park to express preferences related to various attributes of the park management. If travel cost method is widely considered as more robust to valuate recreation than those based on stated preferences (Hanley et al., 1998; Parsons, 2003; Shrestha et al., 2002), choice experiments allow studying more precisely management options. Sometimes described as the "holy grail" of valuation methods (Bennett and Adamowicz, 2001; Carson et al., 2012), choice experiment allows to highlight the trade-offs between many attributes, especially when it comes to management policy including heterogeneous aspects of spatial organization.

The paper is organized as follows. In section 2 we present the material and methods by describing the choice experiment design, the survey carried out in Bãngr-weoogo and data. The section 3 presents the results that will be discussed in section 4. The conclusion recalls the main results and provides some comments.

2. Materials and methods

2.1.Study area

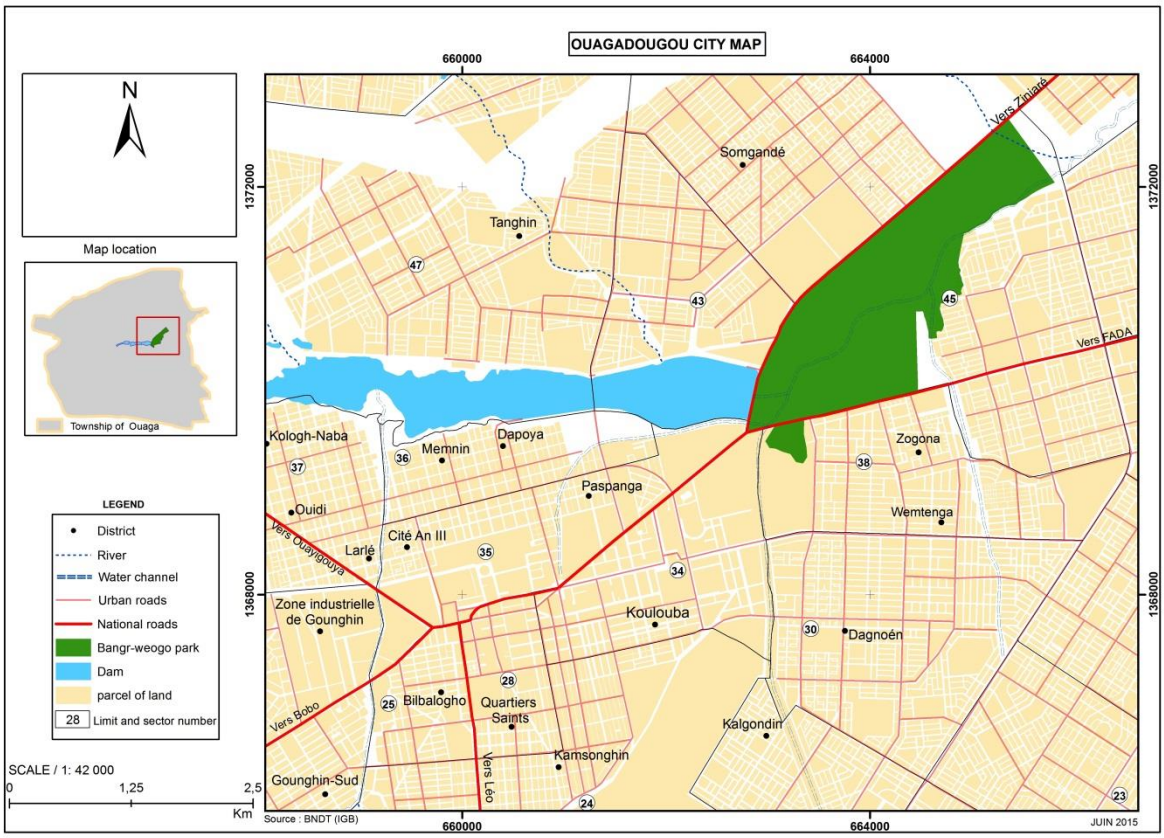
Ouagadougou is the capital and the main economic and cultural center of Burkina Faso. With a population of over 1.6 million (as of 2012), it is the largest city of the country, still rapidly growing. The urban park Bãngr-weoogo is a natural forest dedicated to recreational and educational uses. A former sacred forest belonging, before the colonization, to the Mosse chief, the French colonists, disregarding its local significance and history, established it as a forest in the 1930's, called "Bois de Boulogne", in reference to the well-known urban park in Paris. Formerly located on the outskirts of the city, it is now coined in the urban area, and was

classified in 1936 by the colonial forest administration according to Decree No. 2376/SE. In January 2001, as part of the decentralization process, this classified forest was reassigned to the city of Ouagadougou, with impossibility of alternative use of the site, by the Ministry of Environment and Water, which renamed it “Bãngr-weeogo" ("forest of knowledge" in Mossi language).

The overall objectives were to minimize the risk of damaging Ouagadougou dams’ embankments, and to create a "green lung" in the growing city of Ouagadougou. A walking trail and relaxation area were developed, but the site is also open to environmental education for schools, universities, researchers and visitors, where management experiences are conducted on restoration and protection of biodiversity, including the fight against desertification. The park covers a total area of two hundred and sixty five (265) hectares from which two hundred and forty (240) are equipped, and it plays an increasingly important role for several purposes such as environmental education, research, medicinal plants and ecological services such as carbon dioxide storage (Gnoumou and al. 2008).

The park hosts several ecological formations where trees, woodland and bushland dominate, and also forest gallery along the river and some wetland (Dana, 1990). It is like an oasis in a desert due to the loss of vegetation cover around housing and the importance of its biodiversity: it contains more than 1000 plant species. It also shelters 60 animal families and 225 species of birds. The use of this area, organized in educational units (zoo, nursery, botanical garden, museum), relaxation, leisure and business units are now well-known from local population. However, this area in an urban district is subject to many different land use pressures due to the increase of urbanization and to mismanagement related to the importance of its frequentation (over 300,000 visitors in 2013). Indeed, the fauna and flora are victims of numerous attacks such as logging, bush fires, the presence of plastic waste on the ground and the current flow of motorized vehicles endangering not only animals’ but also users’ lives.

Figure 1: Urban Park Bãngr-Weoogo location



For practical information about the city and the park see http://en.wikipedia.org/wiki/Ouagadougou

It is thus important to identify and implement trade-offs between recreational facilities development, biodiversity protection and cross-effects between these attributes. Economic valuation can help enlighten these tradeoffs. Since the matter is to discriminate among management options, choice experiment appeared as an appropriate technique and was therefore implemented.

2.2.Survey design

The study began in February 2013 with interviews with the urban park manager and five members of organizations that work with him, to identify park's characteristics and develop the questionnaire (see questionnaire in appendix). These people were used as a focus group and the resulting questionnaire has four sections. The first part contains questions related to the environmental attitudes of respondents. The second and most important part contains the "choice experiment". Here, we give information concerning Bãngr-weoogo and the choice sets related to alternative management solutions. It includes descriptions of the five attributes of the choice experiment, i.e. biodiversity level, expected number of visits, number of

relaxing areas, recreational restrictions and entrance fees. The attributes levels are shown in the table 1. The third part addresses some questions related to the motivations for visiting place and activities; and the last section collects respondents' socio-demographic characteristics.

Table 1: Attributes and attribute levels

Attributes	**Level**
1. Number of plants and animals species over the next 5 years	Decrease at 10%  Stable*  Increase at 10% 
2. Expected number of visits	Decrease 250.000 Stable* 300.000 Increase 350.000
3. Relaxing areas	0 1* 2
4. Recreational restrictions	**Without restriction** (cycling, motorized vehicles, levies, birds hunting and no forbidden zone access)  **Current situation*** (cycling and levies)  **Total restriction**
5. Entrance fees	0; 100*; 200; 300; 400; 500

*Current situation

According to the number of attributes and the values they can take, 253,710 profiles ((3 * 3 * 3 * 3 * 6)* (3 * 3 * 3 * 3 * 6 -1) = 253,710) were possible. To present profiles to the respondents in the questionnaire, we applied an efficient design protocol. The problem with this design is that it requires beforehand parameters and the very purpose of the assessment is the estimation of these parameters (ChoiceMetrics, 2012). Thus, we started a pilot survey with D-optimal design that allowed us to get first estimates of the parameters in order to create an efficient design. This first procedure resulted in 18 choice sets that we considered too large

for respondents. Thus we set up the final 3 blocks of 6 choice sets. Each respondent is faced with one of these three blocks, has finally 6 choice sets; each choice being made up of two alternative parks and the present situation (*status quo*).

The numerous existing definitions for biodiversity make its assessment complex (Christie et al., 2006). We must therefore define it in intelligible manner for respondents and Christie et al. (2006), through focus groups, retained four (04) attributes for the description of biological diversity: known species, rare or endangered species not yet known, the protection of habitats and species, and ecosystems process. The analysis showed that only a minority gives a particular value to biological resources like species, habitat or ecosystem services (Christie et al., 2006; Pearce, 2001). In order to better define and present our biodiversity attribute, we examined studies that used biodiversity attribute (see the table below).

Table 2: Biodiversity attributes and main results of related studies

Reference	**Objectives**	**Country (number of questionnaires)**	**Biodiversity attribute**	**Results**
Hanley et al. (1998)	Assess preferences for alternative landscape	United Kingdom (181)	Mix of types of leaves or only evergreen leaves	Mix is preferred
Carlsson et al. (2003)	Identify the attributes that affect the welfare	Sweden (468)	Number of rare species (nothing, little, a lot)	Increasing of rare species number is preferred
Horne et al. (2005)	Evaluate the use value (recreation and aesthetic) and non-use value (biodiversity)	Finland (431)	Number of species (15, 40, 70, 100)	Biodiversity conservation is preferred
Christie et al. (2007)	Assessing preferences for recreational facilities	United Kingdom (1568)	View of wildlife or not	Wildlife view is preferred
Jacobsen et al. (2007)	How to present the biodiversity attributes within choice modeling Icon vs. quantity	Denmark (200)	Protected species number (0, 5, 12, 25); protected particular species (A and/or B)	Iconization overestimates the willingness to pay
Birol et al. (2009)	Assess preferences between water flow reduction, biodiversity and recreation	Poland (192)	Number of species of animals and plants and their population level	Ambiguous results
Jacobsen and Thorsen (2010)	Assess preferences between environmental functions and national park	Denmark (952)	Nature protection level	National park is preferred
Juutinen et al. (2011)	Assess park visitors' preferences between biodiversity and recreation	Finland (473)	Number of species of animals and plants and their population level	Biodiversity level increase is preferred

According to Pearce (2001) remark and after studies examination, a decision had to be made. What would be the description of our attribute referring to biological diversity? We could define biodiversity as rare or iconic or reproducing species, but sometimes they are not known or are so present in the citizens' live that making an evaluation become difficult. In addition, we were unable to identify a specific species or an "icon" to protect. This reinforces our decision to define the biodiversity attribute as the expected number of species of plants and animals and populations in these species over the next 5 years as in Juutinen et al. (2011).

Table 3: Example of choice set

	Park 1	Park 2	Park 3 (status quo)
Biodiversity			
Expected number of visits	250.000	350.000	300.000
Relaxing areas	2	0	1
Recreational restrictions			
Entrance fee	500	200	100
I prefer	○	○	○

2.3.Data

The questionnaire was addressed to visitors in order to obtain operational results for park management. The survey was conducted on-site, in different places of "Bãngr-weoogo", during three weeks in June 2013. We used random sampling and face-to-face interviews, during weekdays as well as weekends at different opening hours. The total number of respondents was 500. Compared to others studies referenced in table 2, this number appears quite acceptable.

174 respondents consistently chose to maintain the current situation. Among them, 25 were removed from treatment. This choice was made according to the follow-up question that asked respondents to give reasons for that choice. We retained the 149 questionnaires of the visitors that explained their choice by the fact that the current situation really suits them or that alternatives do not. As for the 25 questionnaires removed, respondents advanced as a reason the fact that it was not up to them to pay for the park, or it was not up to them to decide how the park should be managed, which were considered protest responses.

The data base finally includes 475 respondents. Among them, there are almost as many men as women, most of whom were nationals. 56% of respondents had a high education level and 40% a secondary level of education. Only 0.2% of them were illiterate. This is due to the fact that the park is located in the heart of the Burkina Faso capital. Regarding employment status, 78% of respondents were students, followed by professionals (nurses, teachers ...) who represented 8% of the sample, and 2% were unemployed. The average age was 24 years, with a maximum of 60. In order not to compel the respondents to directly reveal their income, which is often difficult, they were proposed to place themselves in classes.

Concerning the main activity within the park, 37% of respondents picnic, 29% are studying, 27% are there for landscape and relaxation. Sport which concerns 4.84% comes last. The sample can be considered representative: the questionnaire was addressed randomly across the park and at different opening hours in working days and week-end, and the high number of students reflects the fact that the park is situated not far from the university.

2.4. Models

Morey (1981) showed that the value of leisure depends not only on its price (i.e. the consumer income), but also on its quality (Hanley et al., 2003). The theory of the characteristic value of Lancaster (1966) states that the value provided by a product can be decomposed into the sum of the value of its features taken separately (Adamowicz and Boxall, 1998).

$$U_i = U(Z_i; S_n)$$

$\boldsymbol{U}$, is the utility provided by alternative **i** to individual **n**, **i** ϵ **C** the set of alternatives, $\boldsymbol{Z_{in}}$, the attributes of i and $\boldsymbol{S_n}$ socio-demographic characteristics of **n**.

This theory was combined with the theory of random utility of Thurstone (1927) that states that it is not possible to identify all factors influencing preferences (Baltas and Doyle, 2001). The utility can thus be separated into a deterministic term ($\boldsymbol{V_i}$) which depends on the preferences and the described effect on the alternative level, and a stochastic term ($\boldsymbol{\varepsilon_i}$) that takes into account the unobserved determinants (Bonnieux and Carpentier, 2007).

$$U_i = V_i + \varepsilon_i$$

Of these two theories, the utility provided by **i** can be written:

$$U_i = V(Z_i; S_n) + \mathcal{E}(Z_i; S_n)$$

The probability that an individual chooses the option **i** instead of **j** other options is given by:

$$Pr(i|C) = Pr\left(V_{in} + \varepsilon_{in} > V_{jn} + \varepsilon_{jn}, \forall j \in Cn, j \neq i\right)$$

The economic model underlying this type of equation is intrinsically linked to statistical models (Hoyos, 2010). The specification of the econometric model is linked to the probability distribution of the error term.

Data from the survey was analyzed using conditional logit (CL), latent class logit (LCL) and mixed logit (ML). The conditional logit (LC) is the model used for the analysis of data from the choice experiment (Birol et al., 2009). It assumes that the error term follows a Gumbel distribution and is independently and identically distributed (IID). This law respects the assumption of independence of irrelevant alternatives (IIA) which is compulsory in the random utility theory (Hanley et al., 1998).

The probability that the individual chooses option **i** instead j others is given by:

$$P\,r\left(U_{in} > U_{jn}\right) = \frac{\exp(V_{in})}{\sum_{j \in C} \exp(V_{jn})} = \frac{exp(\beta X_{in})}{\sum_{j \in C} exp(\beta X_{jn})}$$

The latent class model is an alternative of CL which takes into account respondents' preferences heterogeneity. We assume that heterogeneity affects preferences and we need to know the factors explaining this heterogeneity (Boxall and Adamowicz, 2002). In this model, the population is represented as consisting of a finite number of segments or classes. Preferences are assumed to be homogeneous within each class, but are allowed to vary between classes. The number of segments is determined endogenously by the data and the membership to a segment is linked to observable socio-economic characteristics.

The probability $\boldsymbol{P_{ins}}$ that individual n belonging to a segment **S** chooses the alternative **i** is given by:

$$P_{ins} = (P_{in/s}) * (P_{ns}) = \frac{exp(\beta_s X_{in})}{\sum_j exp\left(\beta_s X_{jn}\right)} * \frac{exp(a_s Z_n)}{\sum_s exp(a_s Z_n)}$$

Where

$$(P_{ns}) = \frac{exp(a_s Z_n)}{\sum_s exp(a_s Z_n)}$$

is the probability that the individual n belongs to the segment **S**.

Latent class logit, in the opinion of some authors, underestimates the degree of heterogeneity (Allenby and Rossi, 1998) and the mixed logit (ML) model, developed by McFadden and Train, (2000) has been increasingly used to take into account the heterogeneity of preferences in discrete choice models. It solves the problem of IIA (McFadden and Train, 2000). In the RPL model, utility is given by the formula:

$$U_{inc} = (\beta + \eta_n)X_{inc} + \varepsilon_{inc}\ ,$$

where η_n is the standard deviation of the nth person compared to the average. The probability that an individual chooses option i over option j is given by:

$$P_{ins} = \int \frac{exp(\beta_s X_{in})}{\sum_{j=1}^{J} exp(\beta_s X_{jn})} f(\beta|\theta)d\beta,$$

where $f(\beta|\theta)$ represents the distribution function of β.

However, this model does not offer a clear explanation regarding the source of this heterogeneity (Boxall and Adamowicz, 2002).

3. Results

3.1.Estimation

All parameters from the conditional logit and the mixed logit, except the expected number of visits and the increase of relaxation areas are significant at the 1% risk level. The alternative specific constant (ASC) reflecting the utility associated to the basic choice option is significant and negative. This shows that the *status quo* is preferred on average. Decreasing in biodiversity and relaxing areas reduce the probability of choosing an alternative option; however an increase in biodiversity level raises this probability. Suppression or increasing recreational restrictions level reduces also the probability of choosing an alternative option.

The latent class and mixed logit models allow to expressing the heterogeneity of preferences. With LCL, they are based on the choice of visitors and also on variables such as socio-demographic characteristics that make classes. To build coherent classes while limiting the

number of classes, we have integrated several variables such as age, gender, number of visits per year (frequency), income and socio-professional category. It is possible to create a plurality of classes. To choose the appropriate number of classes and the most efficient model, we relied on the Akaike Information Criterion (AIC) and Bayesian Information Criterion (BIC) and the predictive quality of the model which measures the probability that an individual belongs to the class actually attributed to him.

Table 4: conditional and latent class logit models quality

	Conditional Logit	Latent class model			
		2 classes	3 classes	4 classes	5 classes
Log likelihood	-2177.16	-2025.68	-1960.83	-1927.6	-1903.4
AIC	4374.31	4051.36	3921.65	3855.20	3806.78
BIC	4374.31	4051.36	3921.65	3855.20	3806.78
Predictive quality		0.90	0.88	0.83	0.83

The logit models' quality improves with the number of classes. The better is the model with 5 classes according to the maximum likelihood (log likelihood) and AIC and BIC (the best model is the one that has the lower AIC and BIC). However, increasing the number of classes actually decreases the predictive quality of the model from 90% for 2 classes to 83% for 5 classes. In order to keep the maximum number of significant variables, to facilitate interpretation of results, and to keep a good predictive quality of the model we chose to limit it to 3 classes.

Referring to the significance and the sign of the estimator associated to the ASC, visitors of Class 1 and 2 are indifferent to change (not significant ASC); those of Class 3, with more respondents prefer the current situation.

Table 5: Estimation results

	Conditional Logit	Latent class				Mixed logit	
		Class 1		Class 2		Class 3	
	N=475	N=67		N=131		N=277	N=475	
Attributes								SD of RPL
ASC	-0.845*** (0.129)	-		-		-2,164*** (0.325)	-1.093*** (0.181)	0.181***
Biodiv-	-0.550*** (0.105)	-0.555** (0.245)		-0,711*** (0.166)		-	-0.799*** (0.149)	0.149**
Biodiv+	0.243*** (0.090)	0.388* (0.208)		-		1,350*** (0.261)	0.297*** (0.134)	0.134**
Visit-	-	-0.698** (0.277)		-		-0,760** (0.298)	-	
Visit+	-	-		-		0,807*** (0.286)	-	
Areas-	-0.617*** (0.096)	-1.058*** (0.263)		-		-1,440***	-0.786*** (0.157)	0.157
Areas+	-	-				-	-	
Without restriction	-0.901*** (0.102)	0.808*** (0.209)		-2,129*** (0.213)		-2,275*** (0.281)	-2.378*** (0.310)	0.309***
total restriction	-0.314*** (0.089)	-1.193*** (0.257)		-		-0,854*** (0.204)	-0.692*** (0.187)	0.147***
Entrance fees	-0.0006*** (0.0002)	-0.002*** (0.0006)		-0,0006* (0.0003)		-0,0008* (0.0005)	-0.0009*** (0.0002)	
Classes membership parameters		RRR	P value	RRR	P value	Reference		
Constant		-	0.971	0,436	0.000			
Age		0.858	0.000	-	0.773			
Male		1.374	0.000	0.556	0.000			
Visits' number		0.976	0.000	0.980	0.000			
Average income		-	0.507	-	0.639			
High income		0.125	0.000	1.368	0.004			

executive		-	0.960	0.436	0.000		
Professional or intermediate		-	0.967	0.282	0.000		
Students		-	0.967	0.149	0.000		

***Significant at 1% **significant at 5% *significant at 10% [-] not significant RRR: Relative Risk Ratios ( ) SE

The well-being provided by each characteristic can be assessed through this table. It also helps to know the characteristics of each visitor's class and also to give their preferences over the current situation. The Relative Risk Ratio (RRR) coefficients make them easier to interpret (Cahuzac and Bontemps, 2008). Thus, the younger visitors, the more likely they are to belong to Class 1. Male have 1.154 times greater chance to belong to Class 1 rather than Class 3 compared to women. Individuals with annual low visits of park have a larger chance of being in classes 1 and 2 than in Class 3. Visitors with low income were more likely to belong to Class 1. Executives, students, and those who practice a liberal profession are as likely to be in classes 1 and 3. The unemployed are certain to be found in class 2.

3.2.Welfare analysis

Table 5 allows evaluating park visitors' preferences for different levels of attributes and through the willingness to pay.

$$WTP_{\alpha} = -\frac{dx_p}{dx_{\alpha}} = -\frac{\beta_a}{\beta_p} \text{ ,}$$

where $\boldsymbol{\beta_a}$ is the parameter on the attribute $\boldsymbol{\alpha}$ and $\boldsymbol{\beta_p}$ is the parameter on entrance fee according to the conditional logit and mixed logit estimations. For latent class model, willingness to pay is given by the formula:

$$WTP_{n,\alpha} = \sum_{s=1}^{S} P_{n,s} \left(-\frac{\beta_{a,s}}{\beta_{p,s}}\right),$$

where $\boldsymbol{\beta_{a,s}}$ is the parameter of the attribute α for the class **S**; $\boldsymbol{\beta_{p,s}}$ the parameter on entrance fee for the class **S** and $\boldsymbol{P_{n,s}}$ the probability that an individual n belongs to the class **S**.

Willingness to pay are shown in table 6.

Table 6: Willingness to pay for attributes

Willingness to pay					
	Conditional logit	Latent class model			Mixed Logit
	N=475	Class 1 (N=67) Male, young, low income, low visits number	Class 2 (N=131) Female, high income, low visits number, unemployment	Class 3 (N=277) Older, average income, high visits number	N=475
ASC	-1,408.33	-	-	-2,705.00	-1,261.76 (1.485)
Biodiv-	-916.66	-277.50	-1,185.00	-	-922.66 (-0.518)
Biodiv+	405.00	194.00	-	1,687.50	342.37 (0.647)
Visit-	-	-349.00	-	-950.00	-
Visit+	-	-	-	1,008.75	-
Areas-	-1,028.33	-529.00	-	-1,800.00	-907.55 (0.413)
Areas+	-	303.00	-	-	-
Without restriction	-1,501.66	404.00	-3,548.33	-2,843.75	-2,746.19 (2.388)
Total restriction	-523.33	-596.50	-	-1,067.50	-798.68 (1.177)

Superscript – in link with attributes' name indicates a reduction and superscript + an increase compared with the basic option.
[ ] give the standard deviation for random parameters

According to the conditional logit model, the basic option is preferred and an increase in the biodiversity level is clearly the characteristic which rises most significantly visitors' welfare. Removing or increasing the recreational restrictions decreases visitors' welfare. The current recreational restrictions level is thus clearly the most preferred.

It must be noticed that there is heterogeneity in visitors' preferences according to LCL and ML models. Visitors of class1 and 2 are indifferent to change, but those of class 3 are against it.

In Class 1, the visitors' welfare increases with biodiversity and relaxing areas augmentation. But a reduction of the biodiversity, the expected visitors' number, and the relaxing areas reduce it. Class 1 visitors have a positive willingness to pay for recreational restrictions suppression, and they have a positive willingness to accept compensation for total restrictions (more than the willingness to pay and this bias is admitted in scientific community).

Class 2 visitors appear very specific. They don't pay attention to increasing biodiversity, but their welfare decreases with biodiversity reduction and with recreational restrictions suppression.

Based on the signs of the estimators, Class 3 visitors' preferences are almost similar to the average visitor. Their welfare increases when biodiversity and expected visits number rise. All other feature changes decrease it, and current recreational restriction is preferred.

Note that mixed logit gives visitors' preferences in average but permit to capture preferences heterogeneity. Estimates from this model are close to those of the conditional logit; they have the same signs. It also confirms that visitors' preferences are heterogenic. They are in average for the status quo and against recreational total restrictions but 23%[2] and 28% of them are respectively for the ASC while of them are for the total restrictions of recreational activities.

4. Discussion

According to our results, the current situation appeared generally preferred which shows that the basic alternative described by its characteristics is considered satisfactory by the visitors. Visitors already feel well, which does not prevent positive willingness to pay for some improvements. The most notable result is the statement that visitors are willing to pay for an increase in the level of biodiversity compared to the current level. However, it is important to note the existence of a strong heterogeneity of preferences among park visitors (see table 6) according to latent class logit and mixed logit models. The discussion attribute by attribute is presented below.

Biodiversity

The feature able to improve the visitors' well-being is the biodiversity level increasing at 10% over the next 5 years. The result is consistent with previous studies (Deng et al., 2002; Horne et al., 2005; Juutinen et al., 2011).

Class 1 and Class 3 visitors prefer increasing biodiversity with respective willingness to pay of 194 Fcfa and 1687 Fcfa. The preferences are well related to characteristics such as socio-professional category which strongly linked to education level (Executives, professional or intermediate and students have been more likely found in these classes).

[2] The value of 23% is calculated as $\varphi[-(\text{mean parameter estimate / the random parameter standard deviation})]$ where $\varphi[x]$ is the cumulative standard normal distribution

Recreational restrictions

It is important to note the lack of correlation between recreational restrictions and the level of biodiversity. Hunting only affects birds. So, choosing the suppression of restrictions is in no way contradictory with an increase in the level of biodiversity. Generally, visitors appear against any form of change of the current type of recreational restrictions. However, those from class 1 have their welfare level increased with restrictions suppression. It is important to note that the factor that significantly decreases the level of welfare is the removal of recreational restrictions. This remains consistent with what can be read in the literature (see Adamowicz and Boxall 1998).

Relaxing areas

Considering CL model, visitors dislike suppression of relaxing areas but those of class 2 are indifferent. On the other hand, increasing the relaxing areas is only preferred by class 1 visitors and tolerated by others. Socio-demographic characteristics can explain this heterogeneity. Class 1 visitors are young, with low income and don't like any recreational restrictions. Therefore, relaxing areas can be installed in areas with few rare species where the vegetation is more tolerant to human pressure.

Expected visit number

An important feature is the expected number of visits. A massive increase in the number of visits creates congestion and pressure on resources (Clawson and Knetsch, 1969). This indicator is not significant for all visitors and those of Class 2. Firstly, its decline reduces the welfare of Class 1 and Class 3 visitors'. This is in agreement with the results of Shoji and Yamaki (2004) concerning the reduction of the number of visitors to 50%. On the other hand, its augmentation increases welfare of class 3 visitors. This result is contrary to the study of Juutinen et al. (2011) . This could be explained by the fact that congestion is part of a psychological sensation and visitors at the moment do not feel it. The expression is also mitigated by the construction of secondary parallel roads to old tracks by the current manager. It is equally important to note the need for security, contact and high social behaviour of some visitors.

5. Conclusion

Many studies have focused on natural protected areas in developed countries, and biodiversity has often been the main focus of these studies (Alvey, 2006; Birol et al., 2009; Christie et al., 2006; Horne et al., 2005; Juutinen et al., 2011). Through the use of choice modeling, we study the preferences of the visitors of Bãngr-weeogo for several management options that involve several services related to this park. This study allowed us to identify the trade-offs between park's characteristics and different effects which can exist between several of them.

If the most notable result is that visitors are willing to pay for an increase in the level of biodiversity compared to the current level, a less expected result is the fact that visitors are against the removing of existing recreational restriction. From our results, it is therefore possible to say which is preferred between biodiversity and recreation. While improving biodiversity receives a WTP of 405 Fcfa (0.62 Euro or 0.70 US $), increasing relaxing area does not appear significant, and visitors are opposed to the removal of recreational restrictions. Visitors' preferences seem divided between ecological and recreational oriented intensive management. These two options, a priori divergent, can be reconciled in a city park in the context of developing countries.

The willingness to pay for the increasing biodiversity level was worth 0.43‰ of the GDP in PPP of Burkina Faso for 2013 (about 1638 US $). Juutinen et al. (2011) found a willingness to pay of around 6 Euros for the increasing of biodiversity level in the Oulanka National Park in Finland. It was in accordance to what it is found in most study and corresponded to 0.22‰ of the country GDP in PPP in the same period. Comparing these results, Bãngr-weoogo urban park visitors are willing to pay more part of their GDP in PPP than those of Oulanka Park that is situated in a developed country. Finally, the study shows the existence of environmental incentives in the case of a developing country.

The current situation is preferred by most of visitors, but it is important to notice that visitors' preferences are heterogeneous. Visitors' willingness to pay estimated by conditional logit and mixed logit have the same signs as those of Class 3 gathering most visitors (277 among 475 respondents) and this result is important to consider for public policy design, like public pricing policies. This agreement could not exist. In this case, what should have been used, the results of the average or those of the majority, for the purpose of planning policies?

Furthermore, it is important to remember the hypothetical nature of this study, which focused on five (05) characteristics of the urban park; the others remaining fixed. It is also clear that individuals take into account other characteristics of Bãngr-weoogo such as information boards or distance to their residential location. For a further analysis, it would be interesting to collect secondary data and expand the sample size to non-visitors. Indeed, it would be able to compare the value given to the park with other features of the urban development and other services offered by the city of Ouagadougou.

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Appendix

Bloc 1
N° Enquêté : |___|___|___|

Les informations collectées seront utilisées dans le cadre d'une thèse de doctorat en économie de l'environnement et pourront éventuellement servir au gestionnaire du Parc et aux décideurs politiques. De ce fait, il n'y a pas de bonnes ou mauvaises réponses, seul votre avis nous intéresse.

Pour le déroulement de l'enquête, nous vous prions de suivre les instructions suivantes :

1. Lisez attentivement le questionnaire
2. Répondez personnellement aux questions en cochant la case correspondante à votre choix. Pour certaines questions vous serez appelé à inscrire la réponse dans la zone réservée.
3. Pour plus d'informations, veuillez, vous référer à l'enquêteur et remettez le lui une fois rempli.

Nous vous rappelons que ce questionnaire est anonyme et vous remercions pour l'intérêt que vous accordez à notre enquête !

Réservé à l'enquêteur		
Nom : Prénom:	Contact :	Date enquête :

Réservé à l'agent de saisie		
Nom : Prénom:	Contact :	Date saisie :

SECTION I : ATTITUDES ENVIRONNEMENTALES

1. **A quel point la nature est-elle importante pour vous ?** |___|
   1= Pas du tout important
   2= Un peu important
   3= Assez important
   4= Important
   5= Très important
   6= Autre **(à préciser)**
2. **Combien de fois visitez-vous le milieu naturel par mois (forêt, campagne, sites…)?** |___|
   1= 0 visite
   2= 1 visite
   3= Entre 2 et 4 visite
   4= 5 fois et plus visite
   5= Autres **(à préciser)**

3. Que pensez-vous du rythme de dégradation de l'environnement au Burkina Faso? |___|

1= Pas du tout important
2= Un peu important
3= Assez important
4= Important
5= Très important
6= Autres **(à préciser)**

4. Etes-vous membre d'une association militant en faveur de l'environnement? |___|

0= Non
1= Oui

5. A quel point le Parc Urbain Bãngr-Weoogo est-il important pour vous ? |___|

1= Pas du tout important
2= Un peu important
3= Assez important
4= Important
5= Très important
6= Autre **(à préciser)**

6. quel est votre nombre de visites du parc moyen/an ? |___|___|

7. Combien de temps avez-vous passé ou comptez-vous passer en moyenne au parc lors d'une visite (en minutes) ? |___|___|___|

SECTION II : ALTERNATIVES DE GESTION DU PARC URBAIN BANGR-WEOOGO

Nous voulons à travers les questions suivantes connaitre les préférences des visiteurs pour une meilleure gestion du parc intégrant non seulement la préservation de la biodiversité mais aussi la recréation.

Vous êtes prié de choisir entre des alternatives où la situation actuelle est comparée à deux autres situations (Parcs 1 et 2), différentes selon les caractéristiques suivantes :

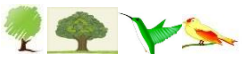
Biodiversité : *elle est pourvoyeur du service culturel dont le loisir en plein air**.** Le parc contient actuellement plus de 1000 espèces végétales et 60 familles animales dont 227 espèces d'oiseaux. Nous la définissons comme étant le nombre d'espèces de plantes et d'animaux et leurs niveaux de populations abritées dans le parc sur les cinq (5) prochaines années ;*

Nombre de visites : *le parc a enregistré une progression régulière du nombre de visites depuis son ouverture en 2001 pour dépasser 300.000 actuellement. Cette augmentation peut, soit se traduire par une concentration de personnes à certaines périodes nécessitant ainsi une règlementation, soit être bien perçue par les visiteurs.*

Nombre d'aires de détente aménagées : *la principale aire de détente est l' « espace du bonheur » qui l'une des installations de loisirs les plus importantes du parc. Le nombre croissant de visiteurs crée un encombrement qui peut être résolu par la construction de nouveaux espaces similaires ;*

Restrictions récréatives : *plusieurs catégories de restrictions prenant en compte la chasse matinale d'oiseaux, l'utilisation d'engins motorisés, le cyclisme, des zones interdites d'accès, les prélèvements à but médical et scolaire (herbiers) sont décrites. Les catégories sont classées De la moins contraignante au plus contraignante.*

Frais d'entrée *: toute gestion et tout aménagement du parc engendre des coûts. Jusqu'à présent, le prix fixé est peu élevé et le parc s'appuie principalement sur les subventions de la commune de Ouagadougou.*

Attributs	**Niveaux des attributs**
1. Nombre d'espèces végétales et animales sur les 5 prochaines années	Diminution  Stable*  Augmentation 
2. Nombre de visiteurs	Diminution 250.000 Stable*300.000 Augmentation 350.000
3. Nombre d'aires de détente aménagées	0 1* 2
4. Restriction récréatives	**Sans restriction** (cyclisme, engins motorisés, prélèvements, chasse matinale et pas de zone interdite d'accès)  **Restriction moyenne*** (cyclisme et prélèvements autorisés)  **Restriction totale**
5. Frais d'entrée	0 100* 200 300 400

***Niveau correspondant à la situation actuelle**

Choix 1	Parc 1	Parc 2	Parc 3 (Parc actuel)
Biodiversité			
Nombre de visiteurs	250.000	350.000	300.000
Aires de détente	0	1	1
Restrictions	Restriction totale		
Frais d'entrée	300	100	100
	○	○	○

Choix 2	Parc 1	Parc 2	Parc 3 (Parc actuel)
Biodiversité			
Nombre de visiteurs	350.000	250.000	300.000
Aires de détente	0	2	1
Restrictions		Restriction totale	
Frais d'entrée	200	400	100
	○	○	○

Choix 3	Parc 1	Parc 2	Parc 3 (Parc actuel)
Biodiversité			
Nombre de visiteurs	350.000	250.000	300.000
Aires de détente	0	2	1
Restrictions			
Frais d'entrée	200	200	100
	○	○	○

Choix 4	Parc 1	Parc 2	Parc 3 (Parc actuel)
Biodiversité			
Nombre de visiteurs	250.000	350.000	300.000
Aires de détente	2	0	1
Restrictions			
Frais d'entrée	500	200	100
	○	○	○

Choix 5	Parc 1	Parc 2	Parc 3 (Parc actuel)
Biodiversité			
Nombre de visiteurs	250.000	350.000	300.000
Aires de détente	1	2	1
Restrictions	Restriction totale		
Frais d'entrée	0	500	100
	○	○	○

Choix 6	Parc 1	Parc 2	Parc 3 (Parc actuel)
Biodiversité			
Nombre de visiteurs	300.000	300.000	300.000
Aires de détente	0	1	1
Restrictions			
Frais d'entrée	400	100	100
	○	○	○

8. Dans le cas où vous auriez choisi de garder que la situation initiale pour tous les choix pouvez-vous nous dire pourquoi ? |___|

1= La situation actuelle me convient parfaitement

2= Ce n'est pas à moi de choisir comment le parc doit être géré

3= Les propositions alternatives ne me plaisent pas ou sont trop chères

4= Ce n'est pas à moi de payer pour cela

5= autres **(à préciser)**

9.1 Quelle est pour vous le parc idéal en termes de biodiversité?

1= faible

2= stable

3= fort

9.2 Quelle est pour vous le parc idéal en termes de nombre de visiteurs ? |___|

1=250.000

2=300.000

3=350.000

9.3 Quelle est pour vous le parc idéal en termes de nombre d'aires de détente aménagées ? |___|

1= Aucune aire de détente

2= Une seule aire de détente

3= Deux aires de détentes

9.4 Quelle est pour vous le parc idéal en termes de restrictions récréatives?

1= Sans restriction (pas de zone interdite, chasse et engins motorisés autorisés)

2= Moyenne

3= Restriction totale

9.5 Combien seriez-vous prêt à payer comme frais d'entrée pour ce parc idéal? |___|___|___|___|

9.6 Pensez-vous que les frais d'entrée serviront à le mettre en place ? |___|

0= Non

1= Oui

9.7 Si non, quelles peuvent être les raisons ? |___|

1= Montant faible

2= Autres (à préciser)

SECTION III : QESTIONS DE FOND

10. Quelle partie du parc avez-vous visité ou avez-vous l'intention de visiter ? |___|

1= Parc zoologique

2= Ménagerie

3= Pépinière

4= Jardin botanique

5= Musée

6= Espace de détente

7= Pistes et le terrain de sport

5= autres **(à préciser)**

11. A quel point ces éléments sont-ils importants pour vous lors de la visite du parc?

Intérêt pour la nature	|___|	**Choisissez une modalité pour inscrire dans le bac** **1=** Pas du tout important **2=** Un peu important **3=** Assez important **4=** Important **5=** Très important **6=** Autre **(à préciser)**
Paysage	|___|	
Etre dans votre élément	|___|	
Bien être mental	|___|	
Se relaxer	|___|	
Fuir la pollution et le bruit	|___|	
Faire des rencontres	|___|	
Etre avec des amis	|___|	
Etre avec la famille	|___|	
Connaitre la forêt	|___|	
Marcher et faire du sport	|___|	
Transmettre l'amour de la nature aux enfants	|___|	

12. Que faites-vous principalement au parc ? |___|

1= Marche/jogging/sport

2= Observation de la nature/animaux/paysage

3= Pique-nique

4= Sortie éducative/étude

5= Autres (à préciser)

SECTION IV : CARACTERISTIQUES SOCIO-DEMOGRAPHIQUES

13. Quel est votre Age ? |___|___|

14. Sexe : |___|

1= Homme

2= Femme

15. Quelle est votre nationalité ? |___|

1= Burkinabé

2= Autres (à préciser)

16. Etat matrimonial : |___|

1= Célibataire

2= En couple

17. Niveau d'instruction |___|

1= Non alphabétisé

2= Alphabétisé

3= Ecole rurale

4= Ecole medersa

5= Ecole primaire

6= Secondaire

7= Université

17. Avez-vous des enfants à charge? |___|

0= Non

1= Oui

17.1 Si oui, combien |___|___|

18. Nombre de personnes dans votre famille |___|___|

18. 1 Combien de personnes dans la famille ont plus de 18 ans |___|

19. Quel est votre lieu de résidence principal (ville)? …….

20. Quel était votre lieu de résidence il y a 5 ans (ville) ?.....

22. Quelle est votre profession ? |___|

1= Agriculteur

2= Ouvrier

3= Profession libérale (commerçant, artisan, employé du privé…)

4= Profession intermédiaire (infirmier, instituteur…)

5= Cadre supérieur

6= Retraité

7= Elèves ou étudiant

8= Sans emploi

9= Autres (à préciser)

23. Quel est votre revenu mensuel individuel en FCFA? |___|

1= 0 à 19.999

2= 20.000 à 34.999

3= 35.000 à 69.999

4= 70.000 à 119.999

5= 120.000 à199.999

6= 200.000 à 299.999

7= plus de 300.000

24. Quel est le revenu global mensuel de votre famille en FCFA? |___|

1= 0 à 34.999

2= 35.000 à 79.999

3= 80.000 à 119.999

4= 120.000 à 199.999

5= 200.000 à 299.999

6=300.000 à 499.999

7= Plus 500.000

Merci pour votre participation !!!

Chapter III: Residential location choice in a developing country: what matters? A choice experiment application in Burkina Faso

Residential location choice in a developing country: what matters?

A choice experiment application in Burkina Faso

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Abstract

This paper evaluates the benefits derived from environmental amenities, and more specifically from urban parks, based on data on residential location choices. The decisions that households make regarding residential location have has important implications for urban economies. This paper uses a choice experiment pivot design (CE) to empirically analyze the trade-off between location attributes such as distance to an urban park and distance to workplace in a the context of a developing country in which environmental questions are generally considered of lower priority and transportation and communication networks are limiting. These characteristics suggest that the "tyranny of distance" is even more significant in this particular context than in larger cities located in more developed countries. Results show that inhabitants are willing to pay more in order to live close to an urban park than to their workplace. Furthermore, I find that preferences are heterogeneous and that the attribute corresponding to the presence of relatives in the area is associated with the highest willingness to pay.

Finally, based on the power criteria of the models used, preference space and willingness to pay space methods generate very similar estimates in this study.

Highlights

- I study the trade-off between residential location choice attributes
- This is the first analysis of residential location choice in Africa that takes into account distance to an urban park and distance to workplace
- I find that reduced distance to environmental amenities (i.e. the park) is associated with a higher willingness to pay than reduced distance to the workplace
- Among all attributes of location choice, the presence of relatives living in the area is associated with the highest willingness to pay estimate

Keywords: Choice experiment, residential location, urban parks, generalized multinomial logit, willingness-to pay space, developing country

JEL: Q23, Q26, C5, R23

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1. Introduction

Urban sprawl and a variety of land use changes have led to environmental impacts that affect not only the sustainability of urban areas, but also the health of the citizens who live there (Barbosa et al., 2012; Dou et al., 2013). The high population density of urban areas creates development pressures on urban green spaces (Jim, 2004) and threatens the provision of amenities that they provide to urban residents. As a result, such green spaces have received increasing attention from urban planners, and urban forests are being transformed into parks that offer essential goods and services for urban development (Baur et al. 2013).

Along with many other major cities in developing countries, Ouagadougou has been experiencing urbanization pressures that are contributing to significant urban sprawl in the area. This sprawl generates not only displacement costs associated with long commutes and traffic congestion, but also health costs associated with high levels of air pollution. Ouagadougou is also home to a large urban park that provides many goods and services to users, and which is currently threatened by the prospect of further residential and industrial development. A prominent local debate is occurring regarding the future of this space. In the context of this situation, this paper estimates the importance of environmental amenities in the residential location decisions made by the inhabitants of Ouagadougou. Many studies have used theoretical models such as Alonso's (1964) monocentric model in order to explain residential location choice, and empirical models such as hedonic price models in order to value a variety of attributes of residential choices.

The main purpose of this paper is to use choice experiment methodology in order to empirically analyze the importance of and values associated with various attributes of residential location choice in the context of a developing country. I am especially interested by the trade-off between living closer to environmental amenities and living closer to the workplace in Burkina Faso. The ongoing development of transport and communication infrastructures in Ouagadougou suggests that the constraints associated with distance are a particularly important issues for residents of the city (Prager and Thisse, 2010), and the high cultural value placed on the presence of a strong community suggests that family ties are very important in this location. It is in that sense that Gervais-Lambony, (1994) stated: “in Africa, city dweller is characterized by loose ties with its significant rural origins and lasting roots in the city.” In the choice experiment literature, the main instrument used to estimate welfare variation has been the measure of “willingness to pay” (preference space). Train and Weeks

(2005) suggested estimating this measure directly through "willingness to pay space" and found that willingness to pay space provides more reasonable estimates of willingness to pay. In later years, Scarpa et al. (2008) and Hole and Kolstad (2012) found that preference space models tend to fit residential data better. The most recent debate in this literature concerns the fact that the strategic behavior of some respondents may produce biased welfares measures. Fiebig et al. (2010) proposed a method that accounts for this source of possible bias. In this study, I explore the attributes of residential location choice through the use of several different models.

It is now widely recognized that urban parks and green areas are of substantial importance in the lives of citizens in large cities (Chiesura, 2004). The presence of natural assets such as parks and forests in urban contexts significantly contributes to an improved quality of life among users (Chiesura, 2004; Kuchelmeister and Braatz, 1993; Kuo and Sullivan, 2001). Most studies using a hedonic pricing method emphasize the fact that housing and property prices are increased by proximity to forests (Mansfield et al., 2005). According to the geographic discounting concept, people seem to consistently prefer to be close to things that they desire (Hannon, 1994), and many authors, such as Bateman et al. (2006) and Hanley et al. (2003), find that recreational value decreases with distance to these amenities. Residing near a forest can thus also be valuable in the context of outdoor recreation.

In this study, I examine residential location choices in the city of Ouagadougou, which contains a natural forest that has been transformed into an urban park called Bãngr-weoogo (265 Ha). The urban commune of Ouagadougou is Burkina Faso's main economic center and has experienced significant environmental degradation over the years. Due to overall losses in the quantity and quality of the natural amenities in the city, Bãngr-weoogo is now considered to be an oasis in the desert. Moreover, although the urbanization rate in Burkina Faso classifies it among the most rural countries in West Africa, Ouagadougou is home to more than 50% of the country's urban citizens (a total of 1,626,950 inhabitants residing within 36,600 ha according to the Ministry of urbanization). Housing is a thus a growing concern and puts significant development pressure on surrounding lands as well as what remains of the green spaces within the city.

The paper is organized as follows. In section 2, I present the specific characteristics of the area under study as well as related literature. Section 3 presents the methods used for data collection and describes the survey design and choice experiment. In Section 4, I present the

econometric specification and the model of willingness to pay. Section 5 presents the results of this analysis, and Section 6 is devoted to a discussion of the results. In the final section, I conclude with a summary of the main results, highlight several implications of these results, and offer my perspective regarding future work on this subject.

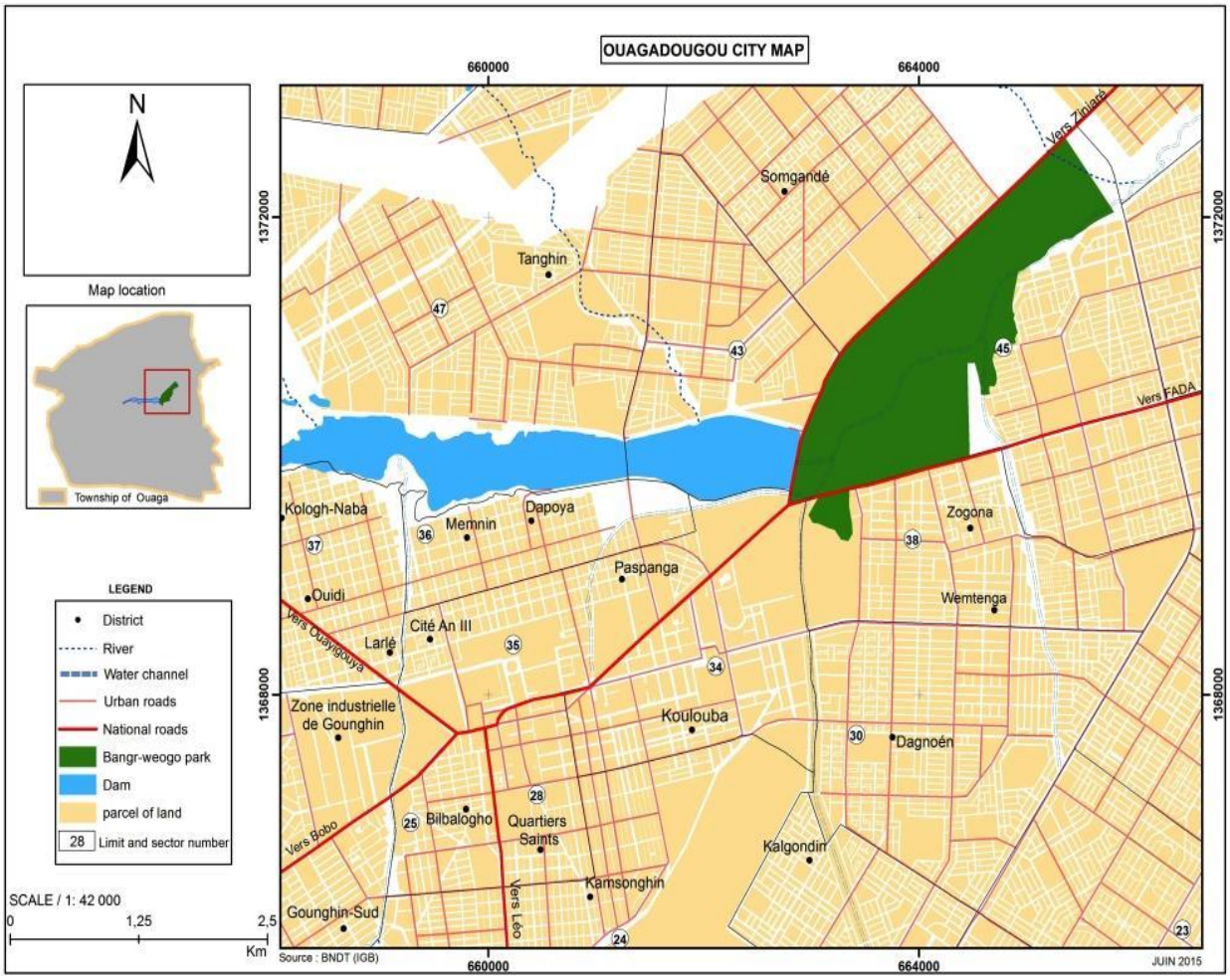
2. Residential location choice literature and housing characteristics in Ouagadougou

2.1. Specific characteristics of Ouagadougou

Ouagadougou, the capital of Burkina Faso, is a growing city and the densest of the country, with 600 inhabitants per km^2 compared to an average of 51.4 at the national level. The city is characterized by a high rate of urban sprawl, which can be attributed to many factors. Population growth is a major source of increased housing needs, and particularly of self-built housing. Taken in conjunction with the isotropic nature of the city, this means that the outskirts of the city experience high levels of development pressure. This situation is compounded by the fact that most new residents prefer to be homeowners and therefore seek empty lots on which to build new homes, which is only possible in periphery. Around 71% of residents in Ouagadougou are homeowners, and about half of homeowners possess legal property papers. Another 11.13% of city residents are tenants, and 16% live in borrowed homes (Boyer and Delaunay, 2009). Living on the periphery of the city can reduce quality of life since it is associated with an increased distance from city amenities and thus increased transport costs and travel time. As a result, a household's choice of residential location is an important determinant of its commuting requirements. It is important to note that Ouagadougou suffers from a lack of adequate transportation infrastructure, both public and private (Boyer and Delaunay, 2009). In the context of urban sprawl and the necessity for further urban improvements, there is significant development pressure on the city's remaining natural assets. The urban park that exists in Ouagadougou today was created from a larger natural forest called the "Bois de Boulogne," from the "Mossi" kingdom that formerly occupied the area. In January 2001, a part of the Bois de Boulogne (265 Ha) was transformed into what is now the urban park Bãngr-weoogo, and opened to the public for recreation purposes and educational activities. Given the environmental degradation the city has seen over the years, the creation of the park was motivated by ecological, human, and social objectives. A formal ban on alternative uses exists for the park, which prohibits certain types

of development (e.g. agricultural plots, houses, and industrial areas). Figure 1 portrays the park location (see below).

Figure 1: Park location



For practical information about the city and the park see http://en.wikipedia.org/wiki/Ouagadougou

2.2. Residential location choice literature

In this section, I present the explanatory variables that can influence a household's choice of residential location.

A city's size and structure are the result of a balance between centripetal forces (e.g. natural advantages, market size, etc.) and centrifugal forces (e.g. competition, travel costs, salary costs and land prices, etc.) that affect both the population and economic activities (Krugman, 1996). Choosing a location in which to live is one of the most important decisions made by

households, one that in turn impacts the habits of household members as well as the non-members with whom they interact (Sener et al., 2011).

Work in the urban economics literature shows that choice of residential location is the result of a trade-off between accessibility to city services (e.g. jobs, public goods), housing costs, as well as the presence of undesirable nuisances and desirable amenities such as landscapes (Brueckner et al., 1999). Accessibility to the workplace and social quality of the neighborhood are the extrinsic attributes that have been shown to have the greatest impact on residential choice (Cavailhès, 2005). Other studies have highlighted the role of distance from the workplace in housing choice (Horner, 2004, 2003; T.-K. Kim et al., 2005a), and it has been demonstrated that the remoteness of the workplace has consequences for households in terms of time and money (Nowotny, 2011). Indeed, when distance to the workplace increases, individuals tend to relocate (Renkow and Hoover, 2000; Van Ommeren et al., 1999). However, working in the city while living in the outside the city is an increasingly common part of the modern lifestyle (Cavailhès, 2009). The attractiveness of suburban areas can be explained by preferences for green amenities and the better living environments that more space generally affords (Cavailhès and Brossard, 2007; Nechyba and Strauss, 1998).

Thus, a household's choice in residential location can be explained by several factors including but not limited to dwelling size, price, neighborhood, distance to major places of interest, and distance to the workplace. Tradeoffs between these factors are an inherent aspect of residential location choice, and according to Nowotny (2011), one important trade-off is that which is made between environmental amenities and distance to workplace.

One of the non-market valuation techniques that allows for an understanding of house location choice is the hedonic price method. This method identifies the flows of ecosystem services as one of the attributes that contribute to the price of market goods, specifically the price of housing. The discrete choice models developed by McFadden (1978) are an alternative to Alonso's model, which is considered deterministic and relies on the assumption of monocentricity. These types of models make it possible to analyze the trade-offs made by households between location choice variables, and to identify the differing sensitivity of various segments of the population to these different attributes (Frenkel et al., 2013). Many studies have analyzed residential location choices using discrete choice models in the past (Chhetri et al., 2006; Earnhart, 2006, 2001; Frenkel et al., 2013; J. Kim et al., 2005; T.-K.

Kim et al., 2005b; Nowotny, 2011; Tu et al., 2015; Wu et al., 2013), however, to my knowledge, no studies have yet been performed in an African context (see Kim et al. 2005a).

3. The model: choice experiment and experimental design

Studies on residential location choice have utilized both theoretical as well as empirical methods. Among empirical studies, most have modeled choices using versions of the discrete choice model developed by McFadden (1978). In this section, I will describe the choice experiment model used here.

3.1. The choice experiment

The purpose of this study is to estimate variations in household welfare that result from proximity to an urban park and to the workplace. Because these benefits are related to several measurable attributes of housing choice, a choice experiment is the most suitable non-market valuation method by which to analyze these attributes (Hanley et al., 1998). In choice experiments, respondents are asked to make a series of choices, choosing their preferred option from a group of alternatives that includes their current situation, or the "status quo," and a "set of environmental goods options" (Bennett and Adamowicz, 2001). Each alternative is described in terms of the level (qualitative or quantitative) of a variety of attributes (characteristics). Importantly, the inclusion of the cost attribute makes it possible to estimate the marginal value of each of the other attributes in monetary terms. Thus, this design allows for the robust measurement of well-being variations by estimating the relative elasticity of the attributes to the price (Sener et al., 2011).

This methodology is derived from value theory (Lancaster, 1966), which states that the utility provided by a good can be decomposed into the values of its different characteristics (Adamowicz and Boxall, 1998).

$$U_i = U(Z_i; S_n),$$

where U_{in} is the utility provided by alternative i to individual n; i ε C is the set of alternatives; Z_{in} denotes the attributes of i; and S_n represents the socio-demographic characteristics of n.

This theory is combined with the concept of "random utility" (McFadden, 1973) which states that it is not possible to identify all of the factors that influence an individual's utility (Baltas and Doyle, 2001). Utility is therefore divided into a deterministic part, V_{in} , which depends on

preferences and describes the marginal impact of different alternatives on the observable component of utility, and a stochastic part, ε_{in} , with a mean of zero, which is designed to take into account the unobservable component of utility. .

$$U_i = V(Z_i; S_n) + \mathcal{E}(Z_i; S_n).$$

This is the choice experiment model I follow in the experimental design of this study.

3.2. Experimental design and survey data

In this section, I present the experimental design used in this study. It broadly consists in identifying the attributes of residential location choice and the variation in the levels of these attributes. According to the literature, several characteristics may explain residential location choice. These include attributes such as the size of dwelling, the facilities the dwelling is equipped with, features of the surrounding neighborhood, proximity to the workplace, proximity to other places of interest, the presence of pollution and/or amenities, etc. The first step in designing the experiment consisted of conducting interviews with residents of Ouagadougou in order to identify the relevant characteristics of residential location choice in this specific geographic and cultural context. From these interviews, five characteristics were selected, one of which was not commonly found in the literature: the presence of relatives in the area. Limiting the number of attributes included in a choice experiment is recommended in order to minimize cognitive demands made on respondents, as well as for statistical reasons (Bennett and Blamey, 2001). Indeed, according to Louviere et al. (2008), the more attributes included in the choice experiment, the less consistent respondents' choices become. The five attributes retained in this study are defined as follows:

- housing size is an attribute that is commonly featured in the residential location choice literature. Indeed, housing characteristics play an important role in the choice of accommodations and this finding has been confirmed in many studies. Taking into account the fact that the exact amount of surface space was rarely known among the respondents in this sample, and that some dwellings contain only one room, I simply use a reasonable variation in house size as attribute levels and define this attribute as a dummy variable in the analysis;

- presence of close relatives is included in this choice set, which is a specificity of this study. During the interview process, this attribute frequently arose as an important consideration in the choice of housing location, and this suggested that a relative in the area plays a significant role in residential choice. Boyer and Delaunay, (2009) report a respondent comment that corroborates this finding: "In Africa, when you do not have your family next door, you should know that you will suffer." Being in close proximity to relatives is therefore not only socially enjoyable, but may also be beneficial in the case of emergencies or in terms of having access to the types of information that circulate among extended family members, whether in cities or rural areas;

- distance to the workplace and distance to Bãngr-weoogo are our attributes of interest in this study. Several studies have highlighted the important role that distance to the workplace and to other amenities have on residential choice (Earnhart, 2006, 2001; Frenkel et al., 2013; Gayda, 1998; J. Kim et al., 2005; T.-K. Kim et al., 2005a; Ng, 2008; Pérez et al., 2003; Wu et al., 2013). Only a few of these, however, were used simultaneously to explain residential choice (T.-K. Kim et al., 2005a), and this highlights another contribution of the current study. In the choice experiment I design, both of the attributes of interest, i.e. distance to the workplace and distance to the park, vary between three levels (the current distance as well as two variations around it). I take these attributes into account in terms of distances because people tend to understand these better than attributes described in terms of the cost or duration of travel. Note that these attributes are measured in kilometers;

- the price of housing is a crucial attribute for the choice experiment method. It measures the change in the welfare of respondents following a change in the level of another attribute *ceteris paribus*. Whereas renters are typically very aware of the amount they spend on monthly rent, this attribute can be more difficult for owners to quantify. As a result, I asked respondents to consider the type of habitat and the geographical location of their house and to estimate how much rent they would demand if they were to rent their house. This approach allowed me to include homeowners in the same treatment as renters. In this study, I use the percentage change in price as in Phaneuf et al. (2013) and Tu et al. (2015).

I expect that an increase in the rent and a decrease in the housing size may negatively impact inhabitants' wellbeing, and that an increase in housing size and a decrease in the distance to the workplace may positively impact it. I am less certain of how proximity to the urban park in Ouagadougou may interact with distance to the workplace, and specifically whether these

two attributes will exhibit complementarity or substitutability. Finally, as suggested from focus group interviews, I expect that proximity to relatives will have a positive impact on household welfare.

The survey I employ is based on that of Tu et al. (2015) consists of four (4) parts (see questionnaire in appendix). I use a so-called "pivot design" in which the choice sets are built around the level of revealed attributes (Train and Wilson, 2008). The "status quo" and additional attribute levels are specific to each individual. Several other studies have also used the pivot design in choice experiments (see Hensher and Rose, 2007; Hensher, 2004; Train and Wilson, 2008; Tu et al., 2015). Respondents are asked to choose their preferred option from a set of options that includes their current house (the status quo) and a set of other possible houses (the alternatives). This decision scenario is elicited four times. Table 1 summarizes the attributes and attributes' levels.

Table 1: Attributes description

Attributes	Levels
Distance to urban park	1. -50% 2. current 3. +50%
Distance to workplace	1. -50% 2. current 3. +50%
Presence of relatives in the area	1. Yes 2. No
Size of house	1. decrease (-1 room or size) 2. current 3. increase (+1 room)
Price/rent of house	1. -30% 2. -20% 3. -10% 4. current 5. +10% 6. +20%

After the attributes and attribute levels have been selected, I address the experimental design. This includes the generation of the choice sets that the respondent will face. The combination of the above attributes and their levels generates a large number of profiles it is possible to present to each respondent ((3*3*3*2*6)*(3*3*3*2*6-1) = 104,652). Presenting all of these options is obviously unrealistic in terms of both time and cognitive effort. As a result, I applied a D optimal design without interactions (using Ngene 1.1.2), which is an efficient

design without a-priori parameters used to reduce the number of profiles. I create three blocks of four choice sets. Each respondent faced one of these blocks that included four choices. Each set asked respondents to choose from two housing alternatives as well as the respondent's current house (the status quo).

An example choice set is presented in Table 2 (see below).

Table 2: Example choice set

Attributes	Current house	Choice 1	Choice 2
Distance to Urban Park	Current distance	50% less	50% more
Distance to workplace	Current distance	Current distance	Current distance
Presence of relatives	Current Situation	Yes	Yes
Size of house	Current size	Current size	Current size
Price/rent of house	Current price/rent	10% more	20% less
I prefer: **(choose only one please!)** →	□	□	□

The survey was implemented in person in the city of Ouagadougou between July and August 2014. About 300 people were surveyed, yielding 284 completed usable questionnaires for analysis. In order to maximize respondent comprehension of the survey, I targeted inhabitants who were at least 18 years old and who were actively employed. It is important to note although it is difficult to judge the representativeness of my sample, I strived to randomize the geographic scope of the implementation, surveying all sectors of the city outside of the park.

Average respondent age was 30 years. The percentage of men (77.8%) was significantly higher than that of women. There were more owners (52.1%) than renters, but fewer than the city average (about 75% according to Boyer and Delaunay (2009)). In addition, 44.33% of respondents had a low level of income and only 11.27% felt that their location was remote compared to major places of interest. Respondent characteristics are summarized in Table 3 (see below).

Table 3: Respondent characteristics

		Min	Max	Mean	Stand. D
Age (year)		18	62	30.38	7.85
Distance to workplace (km)		1	25	8.26	5.61
Distance to park (km)		1	22	7.86	5.16
House size (number of rooms)		1	12	3.65	2.15
Rent/month (cfa currency[4])		3,000	70,000	70,090	89,826.55
Household size		1	36	4.97	4.15
		Percentage			
Presence of relatives		72			
Male		78			
Owner		52			
Head of household		57			
Single		59			
Safe neighborhood		72			
Major places	**Not near**	11.27			
	Near	35.21			
	Near with good qual.	53.17			
Income	**Low**	44.33			
	Average	35.82			
	High	19.85			
Occupation	**Executive**	23.76			
	Lib. and inter.	63.12			
	Laborer	09.57			
	Retirement	03.55			

In the next section, I present the econometric models and welfare variation analysis.

[4] 1 euros= 655.957 cfa and 1$≈500 cfa

4. Econometric Specification

4.1. Econometric model

In econometric analysis, economic models are linked to statistical models (Hoyos, 2010), and the specification of the econometric model is determined by the distribution of probability of the error term. To treat this survey data, I use the conditional logit (CL), the Latent Class logit (LCM), the Mixed Logit Random Parameter (RPL), and the Generalized Multinomial Logit (GMNL) models. The first two models are constrained by the independence of irrelevant alternatives assumption (IIA), which stipulates that if A is preferred to B, the introduction of a third option C must not make B preferable to A.

The conditional logit (CL) is the basic model used for the analysis of data from choice experiments (Birol et al., 2009). It assumes that the error term "ε" follows a Gumbel's distribution and is independently and identically distributed (IID). This model relies on the assumption of IIA necessary for the theory of random utility (Hanley et al., 1998). In this model, the probability that an individual chooses option "i" over option "j" is given by:

$$Pr(U_{in} > U_{jn}) = \frac{\exp(V_{in})}{\sum_{j \in C} \exp(V_{jn})} = \frac{\exp(\beta X_{in})}{\sum_{j \in C} \exp(\beta X_{jn})}. \ ((i,j) \in C \ and \ i \neq j \ )$$

This model faces some limitations. The "IIA" assumption may be violated for a variety of reasons (such as, for example, the use of correlated attributes). Additionally, although heterogeneity may exist among respondents, this model assumes that preferences are homogenous, and does not take into account possible correlations among error terms (Birol et al., 2009). Taking into account heterogeneity in economic analysis, in contrast, allows for unbiased parameter estimation and demand forecasting because it statistically accounts for variations in individual characteristics (Boxall and Adamowicz, 2002). For these reasons, another model will be needed in order to estimate unbiased parameters.

The latent class logit model presents an alternative to the conditional logit. In this model, the population is represented as a finite number of segments or classes. Because heterogeneity among individuals is understood to affect preferences, it is necessary to first identify the factors that drive this heterogeneity (Boxall and Adamowicz, 2002). The heterogeneity of preferences is represented by an endogenous, unobservable (i.e. latent) distribution of the categories that characterize respondents (Bonnieux and Carpentier, 2007). Preferences are assumed to be homogeneous within each class, but are allowed to vary between classes. The

number of classes is determined endogenously by variations within the data, and classes are assigned according observable socio-economic characteristics. The probability $\boldsymbol{P_{ins}}$ that an individual n belonging to segment s chooses the alternative "i" is given by:

$$P_{ins} = (P_{in/s}) * (P_{ns}) = \frac{exp(\beta_s X_{in})}{\sum_j exp(\beta_s X_{jn})} * \frac{exp(a_s Z_n)}{\sum_s exp(a_s Z_n)},$$

with

$$(\mathrm{P_{ns}}) = \frac{exp(a_s Z_n)}{\sum_s exp(a_s Z_n)},$$

where $\mathrm{P_{ns}}$ is the probability that an individual n belongs to segment s and has socio-demographic characteristics Sn (Boxall and Adamowicz, 2002).

The mixed logit (RPL) model, developed by McFadden and Train, (2000) has been increasingly used to take into account the heterogeneity of preferences in discrete choice models, and has been successful in this respect over time and across a variety of areas. In most cases, respondents' utility follows a multivariate normal distribution. Estimation under these conditions is easier, and the mixed logit model solves the problem of IIA (McFadden and Train, 2000). In addition, the latent class logit, in the opinion of some authors, underestimates the degree of heterogeneity that may be present in a sample (Allenby and Rossi, 1998). In the RPL model, utility is given by the formula:

$$U_{inc} = (\beta + \eta_n) X_{inc} + \varepsilon_{inc},$$

where η_n is the standard deviation of the $\mathrm{n^{th}}$ person compared to the average. The probability that an individual chooses option i over option j is given by:

$$P_{ins} = \int \frac{exp(\beta_s X_{in})}{\sum_{j=1}^{J} exp(\beta_s X_{jn})} f(\beta|\theta) d\beta,$$

where $f(\beta|\theta)$ represents the distribution function of β.

Varying coefficients imply a change in the preferences of individuals, thus taking into account this heterogeneity in preferences. However, this model does not offer a clear explanation regarding the source of this heterogeneity (Boxall and Adamowicz, 2002).

According to Louviere et al. (2008), although the use of the mixed logit model has become increasingly common, its use of a multivariate normal distribution can lead to incorrect

specification if this distribution does not take into account heterogeneity. They argue that all of the weight of heterogeneity is captured by a pure scale effect (meaning that for some respondents, the scale of the idiosyncratic error term is greater than for others) and some respondents can make choices randomly. Given this, I choose to use the Scale multinomial logit (SMNL) model and the GMNL model, which combines the SMNL and mixed logit models and allows for better estimations (Fiebig et al., 2010). The GMNL model is best able to account for the extreme behavior of some respondents (e.g. respondents who favor very low or very high levels of one attribute) and very random choices (as evidenced by large idiosyncratic error terms).

In the GMNL model, the utility function is expressed as:

$$\beta_n = \sigma_n \beta + \eta^* ,$$

where σ_n captures the scale of the heterogeneity of an individual's preferences and η^* captures the residual taste heterogeneity.

Econometric estimations based on this specification enable me to calculate the marginal willingness to pay for the attributes included in this study. This analysis is presented in the next section.

4.2. Modeling willingness to pay and willingness to pay space

Marginal willingness to pay estimates measure respondents' preferences for the various attributes of location choice. There are two ways to calculate these estimates. The first is called marginal willingness to pay and can be calculated using the CL and the LCL models. It is obtained through:

$$WTP_\alpha = -\frac{dx_p}{dx_\alpha} = -\frac{dV/dx_\alpha}{dV/dx_p} = -\frac{\beta_a}{\beta_p},$$

where x_α and x_p refer to the attribute α and the monetary attribute, respectively, and βα and βp their parameters as estimated by the conditional logit.

Using the latent class model, the average marginal willingness to pay is estimated for each class, where classes are constructed according to observable individual characteristics. For an individual n, the marginal willingness to pay is:

$$CAP_{n,\alpha} = \sum_{s=1}^{S} P_{n,s}\left(-\frac{\beta_{a,s}}{\beta_{p,s}}\right),$$

where s is the class, $\beta_{\alpha,s}$ is the estimated parameter for attribute α in class s, $\beta_{p,s}$ is the monetary attribute parameter in class s, and $P_{n,s}$ is the probability that individual "n" belongs to class s.

In the case of the Mixed Logit and GMNL models, the above ratios provide a skewed distribution of willingness to pay. Thus, Train and Weeks (2005) suggested an estimate of willingness to pay space. Previous studies have shown that this estimate is more realistic and exhibits a low distribution density at extreme values (Tu et al., 2015). The "willingness to pay space" approach consists of reformulating the utility function.

In this study, the value of the utility of individual n, choosing housing option "i" from the set of selection C is given by:

$$U_{inc} = -\alpha_n p_{inc} + \beta'_n X_{inc} + \varepsilon_{inc}\,,$$

where p_{inc} represents the monetary attribute and X_{inc} represents the vector of other non-monetary attributes in the model. Elements α_n and β_n are the estimated parameters associated with these attributes, and ε_{inc} is a random error term identically and independently distributed to extreme values with a variance:

$$Var(\varepsilon_{inc}) = k_n^2\left(\frac{\pi^2}{6}\right)$$

for k_n^2 , the scale parameter of the n^{th} individual.

Dividing the utility equation by k_n, I obtain:

$$U_{inc} = -\lambda_n p_{inc} + c'_n X_{inc} + \gamma_{inc}\,,$$

for $\lambda_n = \alpha_n/k_n$, $c_n = \beta_n/k_n$. This corresponds to the model where the WTP for an attribute is obtained through the ratio $\gamma_n = c_n/\lambda_n$.

This equation is equivalent to the following:

$$U_{inc} = \lambda_n[-p_{inc} + \gamma'_n X_{inc}] + \varepsilon_{inc}$$

In this case, before estimating the random parameter model, the model is configured a priori, and thus directly yields the marginal WTP, or WTP space, instead of the attribute coefficients β_n , and the monetary attribute is normalized to 1.

5. Estimation results

This section is devoted to the econometric results and welfare analysis. I begin by presenting the model estimates.

5.1. Estimation results

In total, 284 questionnaires are used in this analysis. The survey was conducted randomly with people aged 18 and over in Ouagadougou, Burkina Faso. Attributes such as "presence of relatives," and "dwelling size" are coded as categorical dummy variables in order to facilitate the processing and interpretation of results.

The first model used is the conditional logit, which considers all preferences as homogeneous. According to Hausman's test, the IIA assumption is respected at the 5% level (see test result in appendix).

The parameters obtained from this model are almost all significant (at the critical threshold of 1%), except for dwelling size and the Alternative Specific Constant (ASC), reflecting an indifference to change. Thus, increased distance to the urban park or to the workplace reduces the likelihood of choosing an alternative house. Additionally, having a relative in the area increases the chances of choosing an alternative. As expected, increases in rent (captured by the monetary attribute) reduce the probability of selecting an alternative (see table 5 below).

To take into account inhabitants' heterogeneity in preferences, I use a latent class logit model. In order to define coherent classes while limiting the number of variables, I considered several variables such as being head of household, being a homeowner, feeling safe in one's neighborhood, proximity to and quality of major places of interest (not near, near, near with good quality), gender, age, marital status (couple and single), occupational category (intermediate, executive, laborer, and others), and total household income.

In order to choose an adequate number of classes and the most powerful model, I based my choice on Akaike and Bayes criteria and the predictive quality of the model that measures the probability that an individual effectively belongs to the assigned class. The quality indicators of each model are presented in Table 4.

Table 4: Model selection criteria

	Conditional logit	Latent class logit		
		2 class	3 class	4class
Log likelihood	-1,149.001	-1037.09	-1,010.88	-973.68
AIC	2,312.001	2,081.860	2,021.776	1,947.350
BIC	2,354.900	2,081.860	2,021.776	1,947.350
Predictive quality	-	0.94	0.93	0.94

Upon examining all of the criteria, an increase of number of classes is associated with an increase in the quality of the model. In order to retain the maximum number of significant variables and to facilitate the interpretation of results while maintaining a high quality model, I selected the model that uses 3 classes. The results are shown in Table 5.

Table 5: Estimation results

	Cond. Logit LL: -1149.001	**Latent class model LL: -1010.88**				
		Class 1		**Class 2**		**Class 3**
	N=284	**N=106**		**N=67**		**N=111**
Attributes						
ASC	-0.023 (0.075)	-0.038 (0.111)		0.473 *** (0.154)		-0.491 *** (0.190)
Distance to workplace	-0.022 ** (0.010)	0.023 (0.015)		-0.135 *** (0.027)		-0.051 ** (0.022)
Distance to park	-0.033 *** (0.011)	-0.038 ** (0.015)		-0.001 (0.022)		-0.114 *** (0.030)
Presence of relatives	0.681 *** (0.083)	0.284 * (0.148)		1.777 *** (0.219)		1.062 *** (0.185)
Decrease in house size	-0.761 *** (0.115)	1.145 *** (0.249)		0.362 (0.257)		-3.878 *** (0.470)
Increase in house size	0.043 (0.093)	2.030 *** (0.231)		0.771 *** (0.240)		-1.794 *** (0.214)
Rent	-0.699 *** (0.240)	-1.474 *** (0.365)		-1.139 ** (0.549)		0.552 (0.540)
Class membership		**RRR**	**P value**	**RRR**	**P value**	***Reference***
Head of household		0.66	0.002	-	0.972	
Owner		0.45	0.000	0.316	0.084	
Safe neighborhood		0.56	0.000	3.65	0.000	
Places near		0.48	0.000	0.21	0.000	
Places near with quality		1.05	7.555	0.89	0.584	
Male		1.39	0.008	-	0.982	

Age		1.02	0.003	1.07	0.000	
Single		0.40	0.000	1.74	0.000	
Intermediate		1.79	0.030	-	0.976	
Executive		1.49	0.173	-	0.976	
Laborer		5.41	0.000	-	0.977	
Average income		1.73	0.000	0.48	0.000	
High income		1.15	0.228	-	0.985	

*Significant at 10% **significant at 5% ***significant at 1% [] not significant ( ) standard deviation RRR: Relative Risk Ratios

According to relative Risk Ratio (RRR) in Table 5, homeowners are more represented in Class 3 than in the other two classes. People in Class 2 consider their neighborhood to be safer relative to those in the other classes. Inhabitants with average income levels are more likely to be in Class 1, while those with low income levels are more likely to be in Class 2. Those in Class 3 state that they are located nearer to basic social services with good quality compared to others. Older respondents are more likely to be in Class 2, and the male/female ratio is higher in Class 1 than in other classes.

The insignificance of the ASC parameter indicates that people are on average indifferent to changing their residential location. While this estimator is not significant for Class 1 respondents, it is significant for Classes 2 and 3, which exhibit a positive and negative sign, respectively. This reflects an indifference to change among respondents in Class 1, a preference for change among respondents in Class 2, and a preference for the status quo among respondents in Class 3.

As expected, an increase of the distance to the workplace decreases the chance of choosing another dwelling except among respondents in Class 1, who appear to be indifferent to proximity to the workplace. In addition, any increase in the distance to the park decreases the likelihood of choosing the alternative, except among respondents in Class 2, who are indifferent to proximity to the park. Having a relative in the area increases the likelihood of choosing an option, and an increase in rent decreases this likelihood. With respect to house size, there is an ambiguous effect across classes. On average, however, people prefer not to decrease house size, but remain indifferent to increasing house size. Note that the monetary attribute is not significant among respondents in Class 3, which can best be explained by the fact that there are more homeowners in this class than in the other two.

In this section, I commented on the direction of change without addressing the magnitude of these marginal effects. The next section addresses my main interest in this paper, that is, the assessment of preferences through marginal willingness to pay.

5.2. Welfare analysis

Here, I estimate variations in welfare through the monetary valuation of respondents' preferences for the various residential attributes. This estimation is accomplished through the marginal willingness to pay and the marginal willingness to pay space methods described above. Results are shown in Tables 6 and 7 (below). The final willingness to pay[5] is obtained by multiplying the estimator by the average rent.

Table 6: Marginal willingness to pay and willingness to pay space

Marginal willingness to pay				
	CL LL: -1149.001	Latent class model LL: -1010.88		
		Class 1: Indiff.	Class 2: Pro-change	Class 3: Pro-status quo
Average rent	**70,090**	**72,205**	**41,321**	**85,360**
ASC	-	-	**0.415***	
Distance to workplace	**-0.032****	-	**-0.996*****	
Distance to park	**-0.047*****	**-0.026****	-	
Presence of relatives	**0.974*****	**0.193***	**1.560*****	
Decrease in house size	**-1.088*****	**0.777*****	-	
Increase in house size	-	**1.377*****	**0.677*****	

*Significant at 10% **significant at 5% ***significant at 1% [-] not significant

[5] For distance to park in GMNL (2) for example, the WTP = β_k* Average rent = 0.09 * 70,090= 6.308Fcfa (about 10 euros).

Table 7: Preference space and willingness to pay space in random parameters

	Preference space		Willingness to pay space							
	RPL **LL : -1098** **AIC: 2223** **BIC: 2309**		**RPL(1)** **LL : -1100** **AIC: 2224** **BIC:2298**		**GMNL(1)** **LL: -1098** **AIC: 2225** **BIC: 2318**		**RPL(2)** **LL: -1085** **AIC: 2199** **BIC: 2284**		**GMNL(2)** **LL : -1081** **AIC: 2194** **BIC: 2292**	
	WTP	Std. dev. of random parameters	WTP	Std. dev. of random parameters	WTP	Std. dev. of random parameters	WTP	Std. dev. of random parameters	WTP	Std. dev. of random parameters
Distance to work*rent							4.4.10-7** ($1.91.10^{-7}$)		$4.3.10^{-7}$** ($2.06.10^{-7}$)	
Distance to park*income							0.034 (0.024)		0.026 (0.018)	
ASC	-0.170 (0.132)	1.197***	-0.154 (0.122)	1.026***	-0.143 (0.121)	1.148***	-0.168 (0.123)	1.041***	-0.233** (0.114)	1.012***
Distance to workplace	-0.035*** (0.017)	0.084***	-0.039** (0.016)	0.071*	-0.046* (0.019)	0.072**	-0.068*** (0.021)	0.058	-0.071** (0.028)	0.103***
Distance to park	-0.036** (0.019)	0.102***	-0.043** (0.017)	0.073**	-0.046* (0.024)	0.065	-1.01** (0.044)	0.062**	-0.090** (0.044)	0.052**
Presence of relatives	1.027*** (0.169)	1.457***	1.124*** (0.160)	1.333***	1.053*** (0.377)	1.319***	1.138*** (0.166)	1.409***	1.079*** (0.343)	1.333***
Decrease in house size	-1.192*** (0.026)	1.791***	-1.126*** (0.206)	1.411***	-1.223** (0.496)	1.533***	-1.246*** (0.232)	1.560***	-1.073*** (0.370)	1.021***
Increase in house size	0.063 (0.168)	1.615***	0.097 (0.161)	1.606***	0.004 (0.169)	1.539***	0.060 0.166)	1.660***	0.131 (0.142)	1.280***

*Significant at 1% **significant at 5% ***significant at 10% [] not significant

As is evident in Tables 6 and 7, many variables are significant and have the same sign in all models. With the exception of the ASC in GMNL (2), which is the GMNL model with fixed parameters, the direction of these signs are in line with our expectations. Moreover, the variable “increase in house size” is not significant regardless of the model.

According to Table 7, all models are similar in terms of log-likelihood. In order to determine whether preference space or willingness to pay space models better fit the data, I compare these models on the basis of Akaike and Bayes criteria in the RPL and RPL(1). Log-likelihood and Akaike criteria show that these models are similar, although the Bayes criterion tends to privilege the WTP space model. In order to compare a model that takes scale heterogeneity into account with one that doesn’t, I examine the RPL (2) and GMNL (2) models. While the log-likelihood and Akaike criterion tend to elevate the GMNL, which takes into account the heterogeneity scale, the Bayes criterion privileges the RPL(2). However, the GMNL (2) model exhibits a significant ASC, with 59% of respondents who rejected it.

The negative signs associated with proximity to the workplace and proximity to the park show a loss of well-being regardless of the model. This indicates that the farther a residence is located from either the park or the workplace, the lower the well-being of the household. I cross the variables "distance to the park" and "distance to workplace" in the RPL and GMNL models in order to determine their degree of dependency. This interaction variable is non-significant and reflects the fact that these attributes are neither substitutable nor complementary. Rather, they appear to be independent. Furthermore, an increase in distance to the park is associated with a higher willingness to accept than an increase in distance to the workplace. In addition, this interaction variable led to a decline in the quality of the model, and thus I do not include this term in the final specification. The insignificance of this interaction term can be explained by the fact that I didn’t take the possible interaction between these two attributes into account when designing my choice sets.

The attribute “presence of relatives” receives the highest willingness to pay and highlights the importance of this sociological aspect in a developing country such as Burkina Faso, where social ties remain important regardless of the place of residence (urban or rural). The attribute that receives the greatest willingness to accept in all models is the reduction in the size of the dwelling. The loss in utility associated with a decrease in house size is significant, especially considering that 35% of respondents are already unsatisfied with the size of their current residence.

The crossed variable "distance to work*rent" in Table 7 measures households' sensitivity to distance to the workplace as rent changes. This variable is significant and positive, which indicates that an increase in distance to the workplace is accompanied by a reduction in rent. In other words, an increased rent would push people to move further from their workplace in order to seek a lower rent.

The crossed variable "distance to the park*income" in Table 7 measures a households' sensitivity to increasing distance to the park as income changes, and is not significant. Thus, an increase in income does not necessarily lead respondents to move either closer to or further from the park.

Finally, standard deviation values in the RPL and GMNL models demonstrate that preferences are in fact heterogeneous in this sample. In the case of the GMNL (2) model for example, more than 75%[6] of respondents have a positive WTP to live close to their place of work, 96% of people have a positive WTP to live close to the park, and 79% have a positive WTP to have a relative in the area.[7]

6. Discussion and conclusion

Many studies have examined the factors that drive households' residential choices, particularly in developed countries, and heterogeneity of preferences is often assumed in this extensive literature. These studies enable researchers not only to understand the monetary value of different attributes, but also the interactions and tradeoffs between attributes.

In this study I aim to better understand the residential location choices of the inhabitants of Ouagadougou in terms of several targeted attributes, but also whether substitution or complementarity exists between attributes such as the distance to the workplace and distance to an environmental amenity. One important contribution of this study arises from the discovery that family ties are very important to African respondents, and therefore ignoring them in the context of similar residential choice studies would be a mistake. Excepting any errors of omission, this appears to be the first study that uses choice modeling to evaluate the role of green spaces on residential choices in Africa. Choice experiment methodology is in fact the only method able to take into account the trade-offs between socio-demographic and

[6] The value of 75% is calculated as 1-$\varphi[-$(mean parameter estimate / the random parameter standard deviation)] where $\varphi[x]$ is the cumulative standard normal distribution

location variables and to identify the sensitivity of the various population segments to these different attributes (Frenkel et al., 2013). I utilized a pivot method technique to design this choice experiment, which incorporates both the current housing characteristics of respondents as well as hypothetical levels that vary around these characteristics. Changes in well-being were assessed through measures of "marginal willingness to pay" and "willingness to pay space."

The results show that, on average, respondents are indifferent between keeping their current home or moving. The analysis additionally demonstrates that preferences for housing characteristics are heterogeneous in this sample. As has also been found in other studies (Earnhart, 2001; T.-K. Kim et al., 2005a; Tu et al., 2015; Wu et al., 2013), I find that living closer to the urban park, as well as to the workplace increases the well-being of residents of Ouagadougou. However, these two features are neither substitutes nor complements. One somewhat unexpected result is that distance to the park is associated with a higher willingness to accept than distance to the workplace. Indeed, the loss in utility generated by an increase in distance to the park is greater than that generated by an increase in distance to the workplace. The high value that respondents place on proximity to the park may partly reflect the recreational value of Bãngr-weoogo, the assessment of which by the travel cost method can be difficult due to its location in the heart of the city (see Darling, 1973) .

The attribute that reflects the presence of relatives in the area receives the largest willingness to pay regardless of the calculation method used (WTP or WTP Space). Because this attribute has not been empirically studied before now, no reference figures exist for comparison; however, this finding is consistent with African traditions. Indeed, in Burkina Faso, the importance of proximity to family members is well expressed by the saying "I consider an orphan, in the broad sense of the term, one who lives in an area where he has no relatives".

Any substantial increase in rent results in a relocation of residents away from their workplace as demonstrated by the variable "Distance to work*rent" in the RPL(2) and the GMNL(2) models. In other words, inhabitants are willing to pay more when the distance from the house to the workplace decreases. This finding seems intuitive and in line with work by Nowotny (2011), Renkow and Hoover (2000), and Van Ommeren et al. (1999).

The comparison between preference space and WTP space models yields ambiguous results, and further studies are necessary in order to better understand this comparison. To take into account heterogeneity in preferences, I assert that, despite its similarity to the mixed logit in

this study, the generalized multinomial logit model is best suited to take into account preference heterogeneity, as it generates a significant alternative specific constant (ASC).

Results indicate that the characteristics of the dwelling itself remain a very important factor in the likelihood of an alternative being chosen. I was not able to consider all possible characteristics in this study, but I was able to take them into account to some degree through the inclusion of a housing size attribute. On average, people are indifferent to increases in the size of their house (contrary to what has been found by Earnhart 2001; Earnhart 2006; Frenkel et al. 2013). Notably, 65% of respondents are satisfied with their current house size and experience a loss of utility when this size declines.

Basic social services such as the quality of education, presence and quality of health centers, and proximity to major places of interest can also play a role in residential choices. I have taken these into account by including them in the latent class model. Households that are currently located near social services are "pro-status quo" (as in Kim et al., 2005a). Respondents located near social services of especially good quality are indifferent to change (contrary to what Kim et al., (2005a) find), and this may be explained by the fact that, whereas they may have access to good quality social services, they do not consider their neighborhood to be very safe. The owner/tenant ratio is higher among Class 3 respondents, who are also “pro-status quo”. This can be explained by the fact that residential mobility is reduced (Boyer and Delaunay, 2009), especially for owners who are generally reluctant to move due to the high investment that is often required.

I initially hypothesized that preferences may differ between owners and renters, between heads of households and other household members, as well as between those who live far from the workplace and/or the park compared to those who live closer to these places. The conditional logit applied by class confirms these intuitions (see results in the Appendix). In fact, homeowners are not sensitive to rent variation, which is to be expected because they do not pay rent. Overall, homeowners tend to care about proximity to amenities whereas renters do not. The fact that it is more difficult for renters to move may explain this finding. In addition, heads of households are sensitive to both proximity to amenities as well as to rent, while other household members are not. This is also to be expected, the heads of households move to find work and support the other members of the household, who have little to do with decisions regarding residential location. Finally, inhabitants who are farthest from the workplace and/or the park compared to the mean are sensitive to changes in this proximity,

while the others are not. This finding may be explained by the concept of geographical discounting. According to this concept, individuals prefer being close to amenities that they value, which could explain the high sensitivity to changes in this distance among those who are already very far away from these amenities.

This study has implications for urban land-use planning and sheds light on the importance of environmental amenities in residential location choice. By demonstrating that people value proximity to the urban park in Ouagadougou, this study provides evidence that green spaces are indeed considered attractive. Thus suggests, furthermore, that preservation efforts targeting green spaces are likely to meet with widespread public support. These results can be taken into consideration during the course of future development, planning, and afforestation projects in Ouagadougou in which sustainability is a priority.

It is, however, important to keep in mind the hypothetical nature of this study, which focuses on five characteristics of residential choice, and treats all other characteristics as remaining fixed. It is likely that individuals take into account other known or intrinsic characteristics in their location choice in addition to those that were addressed in this study. It would be particularly interesting to deepen the present study by collecting secondary data and expanding the sample size, aiming to include additional variables such as travel cost or travel time, housing size in m^2, and income expressed in monetary units.

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Appendix

Table A1: hausman's test results

-test without alternative 1

```
. estimates store alleqs

. hausman . allcats, alleqs constant

Note: the rank of the differenced variance matrix (3) does not equal the number of coefficients
        being tested (7); be sure this is what you expect, or there may be problems computing the
        test.  Examine the output of your estimators for anything unexpected and possibly consider
        scaling your variables so that the coefficients are on a similar scale.
```

	——— Coefficients ———			
	(b) alleqs	(B) allcats	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
ASC	-.0649765	-.0232507	-.0417258	.0415127
Disttrav	-.0262573	-.0225165	-.0037408	.0047815
Distparc	-.0323476	-.0331188	.0007712	.0036836
Logmoins	11.4024	-.7607115	12.16311	760.2913
Logplus	12.23917	.0433865	12.19578	760.2913
Prespar	.91223	.6808961	.2313339	.1014889
price	-.812585	-.6989342	-.1136508	.1393768

```
                     b = consistent under Ho and Ha; obtained from clogit
          B = inconsistent under Ha, efficient under Ho; obtained from clogit

    Test:  Ho:  difference in coefficients not systematic

                  chi2(3) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                          =        5.41
                Prob>chi2 =      0.1443
```

-test without alternative 2

```
. hausman . allcats, alleqs constant
```

	Coefficients			
	(b) alleqs	(B) allcats	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
ASC	-.139756	-.0232507	-.1165053	.1233224
Disttrav	-.0241046	-.0225165	-.0015881	.0157512
Distparc	-.0445221	-.0331188	-.0114033	.0179631
Logmoins	-.6543353	-.7607115	.1063762	.1809359
Logplus	.1787264	.0433865	.1353399	.1560746
Prespar	.7781857	.6808961	.0972896	.0916961
price	-1.157934	-.6989342	-.4589995	.4331617

```
                b = consistent under Ho and Ha; obtained from clogit
     B = inconsistent under Ha, efficient under Ho; obtained from clogit

Test:  Ho:  difference in coefficients not systematic

              chi2(7) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =        2.87
            Prob>chi2 =      0.8965
```

-test without alternative 3

```
. hausman . allcats, alleqs constant
```

	Coefficients			
	(b) alleqs	(B) allcats	(b-B) Difference	sqrt(diag(V_b-V_B)) S.E.
Disttrav	-.0110744	-.0225165	.0114421	.0149637
Distparc	-.0374655	-.0331188	-.0043466	.0162261
Logmoins	-.7187259	-.7607115	.0419856	.1123441
Logplus	-.1490393	.0433865	-.1924258	.1063145
Prespar	.3983512	.6808961	-.2825449	.0898142
price	-.5985503	-.6989342	.1003839	.3960545

```
                b = consistent under Ho and Ha; obtained from clogit
     B = inconsistent under Ha, efficient under Ho; obtained from clogit

Test:  Ho:  difference in coefficients not systematic

              chi2(6) = (b-B)'[(V_b-V_B)^(-1)](b-B)
                      =       11.86
            Prob>chi2 =      0.0651
```

Table A2: conditional logit

	Owner		Head of household		Distances > average	
	Yes LL : -598.45 N : 149	No LL : -547.03 N : 135	Yes LL : -652.77 N : 161	No LL : -479.59 N : 123	Yes LL : -244.32 N : 62	No LL : -901.27 N : 222
ASC	-0.054	0.018	0.072	-0.18	-0.032	-0.022
Distance to workplace	-0.025*	-0.018	-0.027**	-0.014	-0.031**	-0.012
Distance to park	-0.04**	-0.26*	-0.027**	-0.044**	-0.055***	-0.014
Presence of relatives	0.67***	0.68***	0.82***	0.42***	0.56***	0.71***
Decreasing of house size	-0.83***	-0.69***	0.041***	-1.28***	-0.95***	-0.72***
Increasing of house size	-0.11	0.20	0.27**	-0.22	-0.054	-0.069
Rent	-0.48	-0.93***	-1.10***	-0.12	-0.24**	-0.83***

*Significant at 1% **significant at 5% ***significant at 10% [] not significant

Réalisation d'une enquête sur le choix résidentiel à Ouagadougou/Burkina Faso

Bloc 1 **N° Enquêté |___|___|___|**

PERIODE DE COLLECTE : Juillet 2014

Réservé à l'enquêteur

Nom de l'enquêteur : _____

Date de passage : |____|____| |____|____| |____|____|
Jour *Mois* *Année*

Contact de l'enquêteur : _____

Réservé à l'agent de saisie

Nom l'agent de saisie : _____

Date de saisie : |____|____| |____|____| |____|____|
Jour *Mois* *Année*

Contact de l'agent de saisie : _____

Nous réalisons une enquête pour mieux connaître la valeur que vous accordez au parc urbain Bängr-weeogo, en identifiant vos choix résidentiels. Les informations collectées seront utilisées dans le cadre d'une recherche en économie de l'environnement. De ce fait, il n'y a pas de bonnes ou mauvaises réponses, seul votre avis nous intéresse.
Pour le déroulement de l'enquête, nous vous prions de suivre les instructions suivantes :

1. Lisez attentivement le questionnaire
2. Répondez personnellement aux questions en cochant la case correspondante à votre choix. Pour certaines questions vous serez appelé à inscrire la réponse dans la zone réservée.
3. Pour plus d'informations, veuillez, vous référer à l'enquêteur et remettez le lui une fois rempli.

Nous vous rappelons que ce questionnaire est **anonyme** et vous remercions pour l'intérêt que vous accordez à notre enquête !

A. UTILISATION DE LA NATURE ET DU PARC URBAIN BÃNGR-WEEOGO

N°	Question	Code réponse	Modalités de réponse	Instructions
1	Connaissez-vous le parc urbain Bängr-weeogo ?	|___|	0=Non 1=Oui	Inscrire le code correspondant.
2	Le parc urbain Bängr-weeogo est-il important pour vous ?	|___|	0=Non 1=Oui	Inscrire le code correspondant.
3	A quelle distance se situe le parc de votre lieu de résidence ?	_____ km		Inscrire la valeur en km
4	A quelle fréquence allez-vous au Parc/an ?	|___|	0= Ne fréquente pas le parc 1= Moins de 6 fois 2= Entre 6 et 12 fois 3= Plus de 12 fois	Inscrire le code correspondant.
5	Pour quels motifs êtes-vous allé(e) au parc ?	☐ Promenade de détente ☐ Pique-nique ☐ Faire du sport (jogging, vélo…) ☐ Cueillette, pêche… ☐ Sortie éducative/ étude ☐ Observer la faune et la flore (nature) ☐ Autre raison (précisez) _____		Une ou plusieurs cases peuvent être cochées
6	Comment avez-vous l'habitude d'effectuer cette sortie au parc?	|___|	1=Seul 2=En famille/entre amis 3=Dans le cadre d'activités collectives organisées 4=Autre (à préciser)	Inscrire le code correspondant
7	Comment allez-vous habituellement au parc ?	|___|	1=A pied 2=A vélo 3= A moto 4= En voiture 5= En transports commun 6=Autres (à préciser)_____	Inscrire le code correspondant

A. UTILISATION DE LA NATURE ET DU PARC URBAIN BÃNGR-WEEOGO (Suite)

N°	Question	Code réponse	Modalités de réponse	Instructions
8.1	A quelle fréquence êtes-vous allé(e) à la campagne (milieu rural, village…)/an ?	|___|	0= jamais 1= Moins de 6 fois 2= Entre 6 et 12 fois 3= Plus de 12 fois	Inscrire le code correspondant
8.2	A quelle fréquence avez-vous pratiqué des activités telles que cinéma, musée, concert…/an ?	|___|	0= Jamais 1= Moins de 6 fois 2= Entre 6 et 12 fois 3= Plus de 12 fois	Inscrire le code correspondant
8.3	A quel fréquence avez-vous exercé une activité de loisir en plein air sur d'autres sites naturels (pêche, chasse, cueillette, pique-nique, nage…)/an?	|___|	0= Jamais 1= Moins de 6 fois 2= Entre 6 et 12 fois 3= Plus de 12 fois	Inscrire le code correspondant

B. CARACTERISTIQUES DU LOGEMENT

N°	Question	Code réponse	Modalités de réponse	Instructions
1	Dans quel secteur habitez-vous ?	....	Inscrire le nom de votre quartier.	Inscrire le nom de votre quartier
2	Combien de personnes habitent avec vous?	1. De moins de 18 ans |____|____| 2. De 18 ans et + |____|____| (y compris vous–même)	Inscrire la valeur correspondante	Inscrire le code correspondant
3.1	Etes-vous le chef de ménage ?	|____|	0=Non 1=Oui	Inscrire le code correspondant
3.2	Si Non, quel est votre lien avec lui ?			Inscrire la lien correspondant
4	Vous êtes ?	|____|	0=locataire 1=Propriétaire	Inscrire le code correspondant
5	Depuis combien de temps habitez-vous votre logement ?	|____|____|ans		Inscrire la valeur correspondante
6	Combien de pièces y-a-t-il dans votre logement (au total)?	|____|____| pièce(s)		Inscrire la valeur correspondante (par exemple 2 si vous habitez dans une maison dite chambre-salon)
7	Le montant mensuel du loyer ou la valeur mensuelle estimée si vous êtes propriétaire	|___|___|___|___|___|___|___| FCFA		Inscrire la valeur correspondante
8	La taille de votre logement vous satisfait-elle ?	|____| pourquoi_____	0=Non 1=Oui	Inscrire le code correspondant
9	Avez-vous de la famille à proximité (le quartier où vous vivez) ?	|___|	0=Non 1=Oui	Inscrire le code correspondant
10.1	Est-ce important pour vous d'y avoir de la famille ?	|___|	0=Non 1=Oui	Inscrire le code correspondant
10.2	Trouvez-vous votre zone calme (en termes de sécurité) ?	|___|	0=Non 1=Oui	Inscrire le code correspondant à la modalité
11	Trouvez-vous que les services de base sont proches et de qualité dans votre zone (écoles, centres de santé, marché) ?	|___|	0=Non 1=Oui proche et de qualité médiocre 2= Oui proche et de bonne qualité	Inscrire le code correspondant à la modalité

C- UNE EXPERIMENTATION : VOTRE CHOIX ENTRE VOTRE LOGEMENT ACTUEL ET DES ALTERNATIVES

Pour finir, nous allons maintenant vous présenter une série de logements qui diffèrent seulement par **cinq caractéristiques** et nous vous invitons à choisir parmi **trois logements** celui que vous préféreriez après les avoir examinées attentivement. Nous répétons l'expérience **quatre fois**.

Avant de vous demander de choisir entre les différents logements, nous expliquons comment ces logements sont décrits, en mettant l'accent sur cinq caractéristiques qui sont :

N°	Question	Modalités
1	La distance de votre logement au parc	1= distance actuelle moins 50% ; 2= la distance actuelle ; 3= distance actuelle plus 50%
2	La distance de votre logement à votre lieu de travail	1= distance actuelle moins 50% ; 2= la distance actuelle ; 3= distance actuelle plus 50%
3	La présence d'un parent à proximité (dans le quartier)	0=Non 1=Oui
4	La taille de votre logement (c'est le nombre de pièces de votre logement)	1= diminution de la taille de votre logement 2=la taille de votre logement actuel ; 3= augmentation de la taille de votre logement
5	Le loyer (si vous êtes locataires) ou prix du logement (si vous êtes propriétaire)	1=loyer/prix actuel -30% ; 2= loyer/prix actuel -20% ; 3= loyer/prix actuel -10% 4= loyer/prix actuel ; 5= loyer/prix actuel +10% ; 6= loyer/prix actuel +20%

NB : il ne suffit pas seulement de considérer les caractéristiques du logement. Il faut aussi considérer le loyer/prix d'achat. Les études précédentes montrent que les individus ne prennent pas suffisamment en considération le prix.

C- UNE EXPERIMENTATION : VOTRE CHOIX ENTRE VOTRE LOGEMENT ACTUEL ET DES ALTERNATIVES (Suite)

1. Si vous aviez eu le choix entre votre logement actuel et les deux choix proposés, lequel auriez-vous choisi ?

Situation 1

Caractéristiques	**Logement actuel**	**Choix 1**	**Choix 2**
Distance au lieu de travail	Distance actuelle	50% de plus	50% de moins
Distance au parc	Distance actuelle	Distance actuelle	50% de moins
Présence de parent dans la zone	Situation actuelle	Oui	Oui
Taille du logement	Taille actuelle	Diminution	Augmentation
Loyer ou prix du logement	Loyer ou prix actuel	10% de moins	Loyer ou prix actuel
Je préfère : (ne cochez qu'une seule case) →	☐	☐	☐

Situation 2

Caractéristiques	**Logement actuel**	**Choix 1**	**Choix 2**
Distance au lieu de travail	Distance actuelle	50% de moins	50% de plus
Distance au parc	Distance actuelle	Distance actuelle	Distance actuelle
Présence de parent dans la zone	Situation actuelle	Oui	Oui
Taille du logement	Taille actuelle	Taille actuelle	Taille actuelle
Loyer ou prix du logement	Loyer ou prix actuel	10% de plus	20% de moins
Je préfère : (ne cochez qu'une seule case) →	☐	☐	☐

Situation 3

Caractéristiques	**Logement actuel**	**Choix 1**	**Choix 2**
Distance au lieu de travail	Distance actuelle	50% de plus	50% de moins
Distance au parc	Distance actuelle	Distance actuelle	Distance actuelle
Présence de parent dans la zone	Situation actuelle	Non	Non
Taille du logement	Taille actuelle	Augmentation	Diminution
Loyer ou prix du logement	Loyer ou prix actuel	Loyer ou prix actuel	10% de moins
Je préfère : (ne cochez qu'une seule case) →	☐	☐	☐

€

C- UNE EXPERIMENTATION : VOTRE CHOIX ENTRE VOTRE LOGEMENT ACTUEL ET DES ALTERNATIFS (Suite et fin)

Situation 4

Caractéristiques	**Logement actuel**	**Choix 1**	**Choix 2**
Distance au lieu de travail	Distance actuelle	50% de moins	50% de plus
Distance au parc	Distance actuelle	50% de moins	50% de plus
Présence de parent dans la zone	Situation actuelle	Non	Non
Taille du logement	Taille actuelle	Augmentation	Diminution
Loyer ou prix du logement	Loyer ou prix actuel	20% de moins	10% de plus
Je préfère : (ne cochez qu'une seule case) →	☐	☐	☐

2. Si dans toutes les situations vous avez toujours choisi l'option « logement actuel », veuillez expliquer pourquoi vous avez préféré celle-ci aux deux autres options :

_____

_____

3. Pouvez-vous noter les différentes caractéristiques par ordre d'importance dans vos choix? 5 pour le plus important et 1 pour le moins important sachant que deux caractéristiques ne peuvent pas avoir la même note

Caractéristiques	**Note**
La distance au parc	
La distance au lieu de travail	
La présence d'un parent à proximité (dans le quartier)	
La taille du logement	
Le loyer	

D- Caractéristiques socio-économiques du ménage et de vous

N°	Question	Code réponse	Modalités de réponse	Instructions
1	Sexe	|___|	1=Homme 2=Femme	Inscrire le code correspondant
2	Quel âge avez-vous ?	|___|___|		Inscrire votre âge en nombre d'années
3	Quel est votre état matrimonial?	|___|	1=Célibataire 2=En couple	Inscrire le code correspondant.
4.1	Quelle est votre situation professionnelle principale ?	|___|	1= Agriculteur 2= Ouvrier 3= Profession libérale (commerçant, artisan, employé du privé…) 4= Profession intermédiaire (infirmier, instituteur…) 5= Cadre supérieur 6= Retraité 7= Autres personnes sans activité professionnelle	Inscrire le code correspondant.
4.2	Quelle est la situation professionnelle principale de votre conjoint(e) ?	|___|		
5	A quelle distance se situe votre lieu de travail de votre lieu de résidence ?	_____ km		Inscrire la valeur en km
6	Comment avez-vous l'habitude d'effectuer le trajet vers votre lieu de travail ?	|___|	1=Seul 2=Covoiturage (avec quelqu'un)	Inscrire le code correspondant.
7	Comment allez-vous habituellement au travail?	|___|	1=A pied 2=A vélo 3= A moto 4= En voiture 5= En transports commun 6=Autres (à préciser) _____	Inscrire le code correspondant.
8	Niveau d'instruction	|___|	1=Non alphabétisé 2=Alphabétisé 3=Ecole rurale ou coranique 4=Ecole primaire 5=Secondaire 6=Université	Inscrire le code correspondant.
9	Pouvez-vous indiquer approximativement le revenu mensuel net de votre foyer (en FCFA) ?	|___|	1= 0 à 149.999 2=150.000 à 299.999 3=300.000 et plus	Inscrire le code correspondant.

Nous vous remercions pour votre attention

Chapter IV: Ecosystem services and economic growth: does it pay to conserve natural ecosystems?

Ecosystem services and economic growth: does it pay to conserve natural ecosystems?

Sidnoma Traoré[♦], Jean-Michel Salles[Δ], Mabel Tidball[T]

Abstract

Environmental and resource economists have followed several ways to take into account the role of environment in economic growth. Several studies have involved mainly the consideration of exhaustible resources and pollution as potential limit to growth. However, as noted by Partha Dasgupta, economists mostly neglected nature when modeling economic growth and do not consider it as a form of capital as others. In this paper, we regard nature as a capital and try to understand how different interactions between natural and man-made capitals can affect growth. In addition, the paper highlights the impact of the weight given to natural capital in the production of final good in growth. Our results show that interactions of the two capitals can lead to an endogenous growth or steady state in the long run. Moreover, we found that a production function that relies heavily on natural capital does not break the growth when it appears.

Key-words: Natural capital, Ecosystems, economic growth, optimal control

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1. Introduction

The importance of functional ecosystems for economic development is both a set of interdependencies dynamic still poorly understood, and a widely discussed issue (Costanza and Daly, 1992; Tallis et al., 2008) . Since, the Meadows report to the Club of Rome (Meadows et al., 1972) have triggered the strong economists' reactions (Solow, 1974), it seem widely accepted that the central issue was the dynamics of the resource use (as a consequence of economic and population growth). In more recent years, the debate was often to try to understand if natural (exhaustible) resources richness was a blessing or a curse (Sachs and Warner, 2001; Van der Ploeg, 2011). Though considering ecosystems, we will not try to account for the countless works related to the resource-growth relationship and we could limit our scope to renewable resources, such as forests and fisheries. Despite a significant body of study on the optimal use of resource stocks over time (see Clark (1990)), there has been little interest in understanding how they contribute to economic welfare until recently. The concept of natural capital appeared, for a moment, as an attempt to include nature properly in the modelling of a sustainable development (Costanza et al., 1997; Ekins et al., 2003; Kareiva et al., 2011). But the broad movement initiated by the Millennium Ecosystems Assessment strongly established the category of ecosystem services (ES) to describe and analyze the ways by which human societies derive benefits from ecosystem functioning.

ES refer in a broad sense to the benefits that people obtain from ecosystems (Costanza et al., 1997; Groot et al., 2009; MEA, 2005). Costanza et al., (1998) suggested a more explicit definition: ecosystem services are flows of materials, energy, and information from natural capital stocks which combine with manufactured and human capitals' services to produce human welfare. The interdependencies between nature functioning and human activities are at the core of this concept. Nature is regarded here as a stock, the natural capital, and several authors have noticed that conceptualizing nature as a stock that provides flows of ES may underestimate the difficulty of governing the provision of ecosystem services (Farley and Costanza, 2010; Richard B. Norgaard, 2010; Muradian and Rival, 2012).

Ecosystems contribute to human well-being in many ways that can be classified following different rationale according to the aim pursued. A fundamental opposition led to group them into two main categories that can be qualified as: direct, when they are a direct source of ecological amenities, and indirect, when they are considered a stock of natural capital involved in the production of final services. In the first case, the utility of ecosystems is

mainly related to their natural features; in the second, they contribute as productive factors complementary to capital investment.

In this paper, the focus is essentially on modelling indirect ecosystem services. For years, the challenge of feeding the world in a context of ever increasing demand and scarcity of land (Tilman et al., 2011) have sustained this debate (see Fischer et al., 2008, 2014). One of the basic results is that there is no universal answer and that the most effective strategy depends on the reaction curve of the biodiversity at stake face to anthropogenic pressures.

This paper is not mainly related to this important debate, but we study the relationship between ecosystems and economic growth while combining it with other factors, such as agriculture or recreational facilities. For this, we consider the nature as natural capital that provides ecosystem services and as a non-consumptive production factor. We consider an economy with two types of capitals, natural capital and man-made capital, which contribute to the production of final goods via a joint production function. The agent makes a trade-off between consuming the final good and investing in the maintenance of the two capitals, to maximize the utilitarian criterion represented by a discounted utility function which depends only on the final consumption.

The concept of ecosystem services has been put forward to analyze and communicate about our dependency with respect to functioning ecosystems (Costanza et al., 1997; Daily, 1997; Groot et al., 2002; MEA, 2005). In the literature, ecosystem services are thus mainly highlighted for their positive aspects and therefore the negative impacts that certain aspects of ecosystems functioning can have on human well-being, the so-called "ecosystem disservices", are most often ignored. Few studies have explicitly analyzed ecosystem disservices (Zhang et al., 2007; Lyytimäki and Sipilä, 2009; Dunn, 2010; Escobedo et al., 2011). Zhang et al., (2007) studied some of them, such as the competition for pollination; competition for water and pests damage to agriculture. This bias can be justified by the evidence that at a sufficient level of analysis, the aggregated effects of ecosystems functioning are necessarily positive.

Considering the trade-offs between conservation and production, namely agricultural production, this paper appears related to the "land sparing" vs "land sharing" debate. In a few words, the debate was formally introduced by Green et al (2005) and opposes the land sparing strategy, which consist of separating conservation areas and agricultural production and "*minimizes demand for farmland by increasing yield*", to an approach that aims at conserving biodiversity on farmland though wildlife-friendly farming "*which boosts densities of wild*

populations on farmland but may decrease agricultural yields". Several studies have allowed to deepen our understanding of these two strategies (see Bhagwat et al., 2008; Godfray et al., 2010; Phalan et al., 2011). In this viewpoint, our approach aims at extending this debate by modelling the interactions between goods production and ecosystems conservation in a dynamic perspective.

The economic literature provides many models of economic growth that take into account the natural environment. Many decades after the Meadows Report to the Club of Rome, analysis of the relationship between economic growth and environment remains controversial (England, 2000; Brock and Taylor, 2005; Prieur, 2009). Two major groups of studies are listed in the literature: those on exhaustible resources (Nordhaus et al., 1973; Solow, 1974) and those interested by pollution as a potential limit to the growth (Keeler et al., 1971; Brock, 1977). Thus, for the proponents of the Environmental Kuznets Curve, there is no necessary limits to growth (Stern et al., 1996). But, when exhaustible resources are consumed in the production process, they may create limits growth if substitutions are limited. This statement shaped a recurring opposition between nature conservation and economic growth (Gylfason and Zoega, 2006). The economic growth theories provide a framework to explore the links between current environmental problems and the possibilities for future improvement (Brock and Taylor, 2005).

The specificities of our approach lies mainly in the fact that we consider the environment as a natural capital that acts both as a factor of production and a cause of nuisance, and we focus on specific aspects of the relationship between factors of production. Instead of considering the services provided by nature to man-made capital and conversely, we consider only the negative impacts of one on the other, also called ecosystem disservices.

The purpose of this paper is twofold: firstly, show how the various interactions between production factors affect growth and secondly, highlight the impact of the weight given to nature in the production of final consumption goods on growth. Gylfason and Zoega, (2006) found that a strong dependence on nature causes a decline in savings, capital and production/capita. What about nature weight in a model where nature plays the role of a non-consuming production factor?

The rest of the paper is organized as follows: in the first part, we present the model. The second part highlights the results. At this level, two sub sections emerge. A first one, in which we consider the depreciation of man-made capital and disservices produced by nature are

separated; and a second one in which the man-made capital depreciation rate is a function of Nature. The last section is devoted to results discussion.

2. The model

We consider an economy where production depends on two capitals: the natural capital G and the man-made capital A. Note that G and A are not expressed in physical terms but in values (the currency being the unit of final production). The representative agent combines the two capitals in a production function. Then the production is shared between the consumption of which depends the agent's welfare and investments for the maintenance of the two capitals.

Natural capital stand for the ecosystems and the biodiversity they encompass. We assume that the services that the agent derives from these ecosystems, are not consuming natural capital (the natural capital is not a natural resource). Reciprocally, natural capital is not naturally renewing when degraded by the agents productive investments (destroyed ecosystems cannot regenerate by themselves, a species that has disappeared in a landscape will not spontaneously reintroduce). Man-made capital is classically defined as artificial investments, such as farm equipment or intensive recreational development in forest areas.

Considering agriculture, the agent will combine natural and man-made capitals in order to produce goods that will be consumed or invested. Investing in natural capital may mean financing ecosystems restoration on in a better use of existing ecosystems.

Production technology

Final goods and services are obtained from a homogeneous production function of degree 1, *F(G, A)*: a Cobb-Douglas function of the form:

$$F(G, A) = G^{\alpha} A^{1-\alpha}.$$

Capitals dynamics

There is no natural depreciation of the natural capital ***G*** (think, for example, a natural forest ecosystem with its biological diversity). However, natural capital suffers a degradation due to man-made capital which is proportional to the level of ***A*** (this degradation results of the impact of the man-made capital on natural ecosystem, it is a stock externality). Natural capital

$\boldsymbol{G}$ can be restored by an investment $\boldsymbol{I_G(t) = I_G}$ from the representative agent. The dynamics of G is given by:

$$\dot{G} = I_G - \gamma A.$$

Man-made capital $\boldsymbol{A}$ increases with an investment $\boldsymbol{I_A(t) = I_A}$, from the representative agent. It suffers a depreciation with time (capital erosion), proportional to the level of man-made capital. The man-made capital also suffers from a negative impact of natural capital: the higher the natural capital, the stronger the impact. This can be interpreted as an ecosystem disservice: natural ecosystems tend to accelerate depreciation of man-made capital, proportionally to the level of natural capital. Sometimes, the intensity of disservices depends not only on the level of man-made capital and of natural capital separately, but there is a positive interaction between their levels: the ecosystem stock further limits the productive efficiency of man-made capital with higher intensity when the level of man-made capital rises. This can be interpreted by the idea that the higher is the level of man-made capital, the more ecosystems are disturbed and the more they tend to limit the value of man-made capital. One can imagine, for agricultural production, that highly disturbed ecosystems no longer provide certain basic regulations, such as bio-control; for the whole society, that a strong source of human diseases, for example because of disturbed ecosystems lose biodiversity and provide less control of certain epidemics (such effects are described in the literature). We are going to describe this kind of effect as a negative AG interaction in the derivative of A. One can also consider that fragmented ecosystems (the AG interaction) are more favorable to biological invasions, which will degrade the economic value of man-made capital A.

$$\dot{A} = I_A - \delta_1 A - \delta_2 G - \delta GA.$$

Budget constraint

The agent shares his final production between the consumption of the final good C and the investment I_G for the renewal of the natural capital and I_A for the renewal for the physique capital.

$$F(G, A) = C + I_G + I_A = G^{\alpha} A^{1-\alpha}.$$

The objective function

The representative agent maximizes in C, I_G and I_A, the utilitarian criterion of a discounted utility function U(C) taking into account the dynamics of both capitals and the budget constraint.

$$Max_{I_G I_A c} \int_0^{\infty} e^{-\rho t} U(C) dt. \qquad (1)$$

$U(C)$, the utility function is increasing and concave;

$$U'(C) > 0, \qquad U''(C) < 0,$$

and, the inter-temporal elasticity of substitution in consumption $\eta = -\frac{U'(C)}{U''(C)C}$ is constant; ρ is the discount rate.

We study the behavior of the model in the long run with different dynamics of man-made capital.

3. The model resolution

This section is dedicated to the resolution of the model. For practical reasons that will be explained at the end of the section, we focus on two particular cases that are presented thereafter. These cases are, firstly, the situation when there is no interactive effect $(\delta = 0)$ and, secondly, when there are only interactive effects $(\delta_1 = \delta_2 = 0)$. The practical meaning of these simple cases has been explained above.

3.1. The linear case $(\boldsymbol{\delta = 0})$

In this case, the depreciation rate of the physical capital $\boldsymbol{\delta_1}$ and the depreciation rate related to the ecosystem disservices $\boldsymbol{\delta_2}$ are separable and their effects are additive.

The objective function becomes:

$Max_{I_G I_A c} \int_0^{\infty} e^{-\rho t} U(C).dt$

s/t $\dot{G} = I_G - \gamma A, \qquad \dot{A} = I_A - \delta_1 A - \delta_2 G, \qquad G_0 \; and \; A_0$ given,

and $C = F(G, A) - I_G - I_A$.

The associated Hamiltonian is:

$$H = U(C) + \lambda_G(I_G - \gamma A) + \lambda_A(I_A - \delta_1 A - \delta_2 G).$$

The first order conditions in the steady state are:

$$\frac{\partial H}{\partial I_G} = -U'(C) + \lambda_G = 0, \qquad (2)$$

$$\frac{\partial H}{\partial I_A} = -U'(C) + \lambda_A = 0, \qquad (3)$$

$$\dot{\lambda}_G = \rho\lambda_G - \frac{\partial H}{\partial G} = \rho\lambda_G - U'(C).F_G + \lambda_A\delta_2 = 0, \qquad (4)$$

$$\dot{\lambda}_A = \rho\lambda_A - \frac{\partial H}{\partial A} = \rho\lambda_A - U'(C).F_A + \lambda_A\delta_1 + \gamma\lambda_G = 0, \qquad (5)$$

$$\dot{G} = I_G - \gamma A = 0, \qquad \dot{A} = I_A - \delta_1 A - \delta_2 G = 0. \qquad (6)$$

Proposition 1*: There is a steady state if and only if* $\left(\frac{\rho+\delta_2}{\alpha}\right)^{1/1-\alpha} = \left(\frac{\rho+\delta_1+\gamma}{1-\alpha}\right)^{-1/\alpha}$

The production function is homogeneous of degree 1, if the production factors are increasing, the economy is growing and there is no steady state. In the following, we study the conditions of existence of an endogenous growth.

Let $\mathrm{a} = \delta_1 + \gamma - \delta_2$,

Since all parameters are positive, « a » can be regarded as an indicator of the importance of A relatively to G for the dynamics of the capitals stocks. When « a » is high, the stock A is the main factor that constrains both dynamics. When « a » is low (or negative), G is preponderant.

We obtain the following results.

Proposition 2: Existence and properties of the A/G ratio

There is a unique solution $x = \frac{A}{G} > 0$ *solution of* $f(x) = \alpha x^{1-\alpha} - (1-\alpha)\,x^{-\alpha} + \mathrm{a}$, *with the following properties:*

$$\alpha < \frac{1-\mathrm{a}}{2} \Rightarrow x > 1, \qquad \alpha > \frac{1-\mathrm{a}}{2} \Rightarrow 0 < x < 1,$$

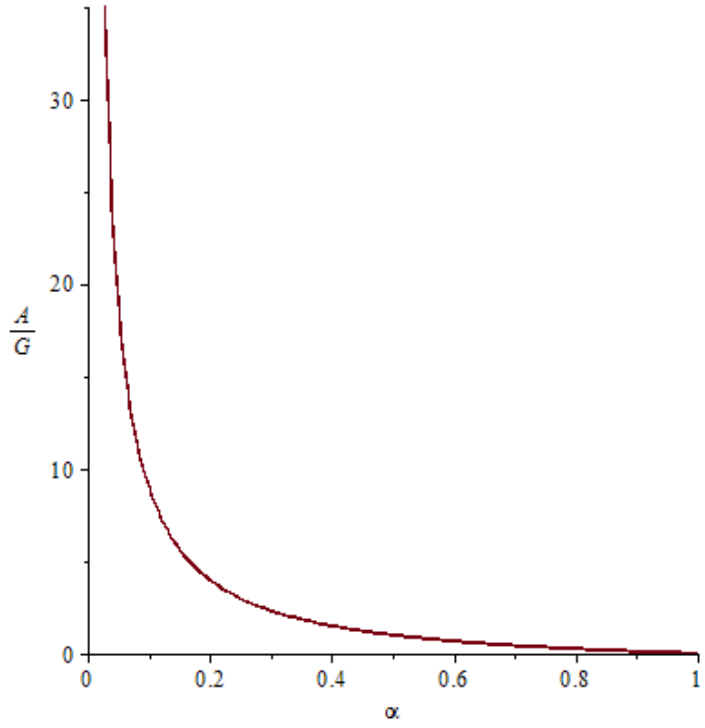
$$\frac{\partial x}{\partial \alpha} = -\frac{x^{1-\alpha} + x^{-\alpha} + \ln(x)\,\mathrm{a}}{\alpha(1-\alpha)(x^{1-\alpha} + x^{-\alpha})},$$

$$\alpha < \frac{1-a}{2} \Rightarrow \frac{\partial x}{\partial \alpha} < 0.$$

When α is small, at the optimum, A is greater than G; because G is especially limiting the dynamics of A and G and therefore the production.

When $a\ tend\ to\ 1$ the ratio x is even small because α which reflects the weight of G is great: it is logical: we get the maximum preserving more G which is the dominant production factor.

Graph 1: x relatively to α



According to simulations results, the curve of $x = A/G$ as a function of α displays a continuous growth of G relatively to A when α increases., The higher the weight of the natural capital G for production, the faster it is growing relatively to the artificial capital A.

Proposition 3: Properties of the growth rate

We know that there exists $x = \frac{A}{G} > 0$ Solution of $\alpha x^{1-\alpha} - (1-\alpha)x^{-\alpha} + a = 0$ (proposition 2)

We can see in the appendix that the growth rate is given by*:*

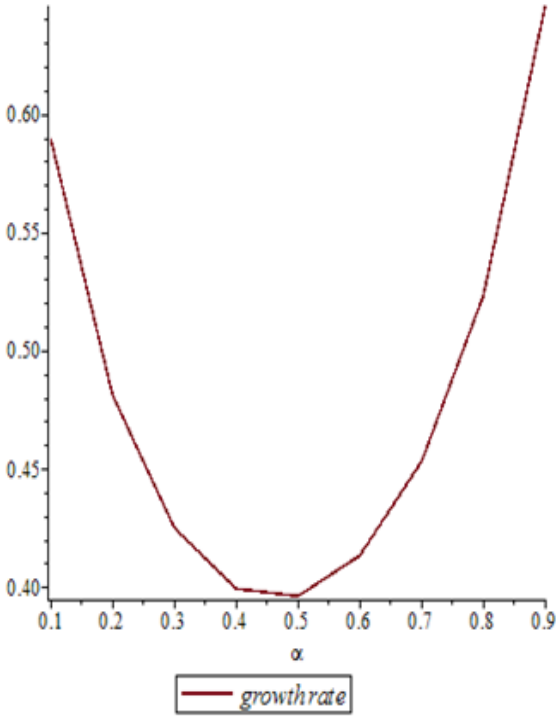
$$r = \frac{\dot{C}}{C} = \frac{\dot{A}}{A} = \frac{\dot{G}}{G} = -\eta\ (\rho - \alpha x^{1-\alpha} + \delta_2) \qquad (7)$$

There are no general results but some properties (see appendix) can be drawn about the growth rate.

$$\alpha < \frac{1-\mathrm{a}}{2} \Leftrightarrow \frac{\partial r}{\partial \alpha} < 0\,, \qquad \alpha > \frac{1-\mathrm{a}}{2} \Leftrightarrow \frac{\partial r}{\partial \alpha} > 0, \text{and } \frac{\partial r}{\partial \mathrm{a}} > 0$$

$$\text{and } \frac{\partial r}{\partial \alpha} = 0 \Leftrightarrow \alpha = \frac{1-\mathrm{a}}{2}$$

Graph 2: growth rate r relatively to α



$\rho = 0.04,\ \delta_1 = 0.05,\ \delta_2 = 0.03,\ \gamma$

Since there are no analytic results for the value of x, simulation of the long run growth rate can be done with numeric values for each parameter. The results can be displayed as a curve relating the long term growth rate of the variables C, A and G as a function of the α parameter. This U-shaped curve passes through a minimum for $\alpha = \frac{1-\mathrm{a}}{2}$. The function is strictly decreasing for α < ½ and strictly increasing for α > ½. The growth rate is then maximal for extreme values of α and minimal for α = ½.

The interpretation of these results is straightforward. When α goes to 0, G plays a negligible role in production and A drives economic growth. In this situation, the equations that determine the dynamics of A and G create incentives for the maximizing agents to invest in A and find a high rate of economic growth based on the accumulation of artificial capital.

Symmetrically, when α goes to 1, A plays a negligible role in production and G drives economics growth. The incentives push the agents to invest in G and it results in a high rate of economic growth based on the development of useful naturel capital. Since the equations are not symmetric, the U-shape curve is not either. On both extremities, the high growth rate can be regarded as the efficiency of two forms of growth, and the one based on natural capital can be seen as "green growth". It is noticeable that the growth rate is higher when α goes to 1 that when it goes to 0. This result can be explained by the fact that A is both depreciated by G and by itself, contrary to G which is only degraded by A. When α is high the agent tend to invest more in G, and when α is small, she tends to invest in A that limits its own growth. This can be seen as a straight consequence of the modelling choice to consider the ecosystems as a capital G which is perennial. This choice was justified above. For intermediate values of α, each capital tends to limit the growth of the other and this may explain why the growth rate appears limited.

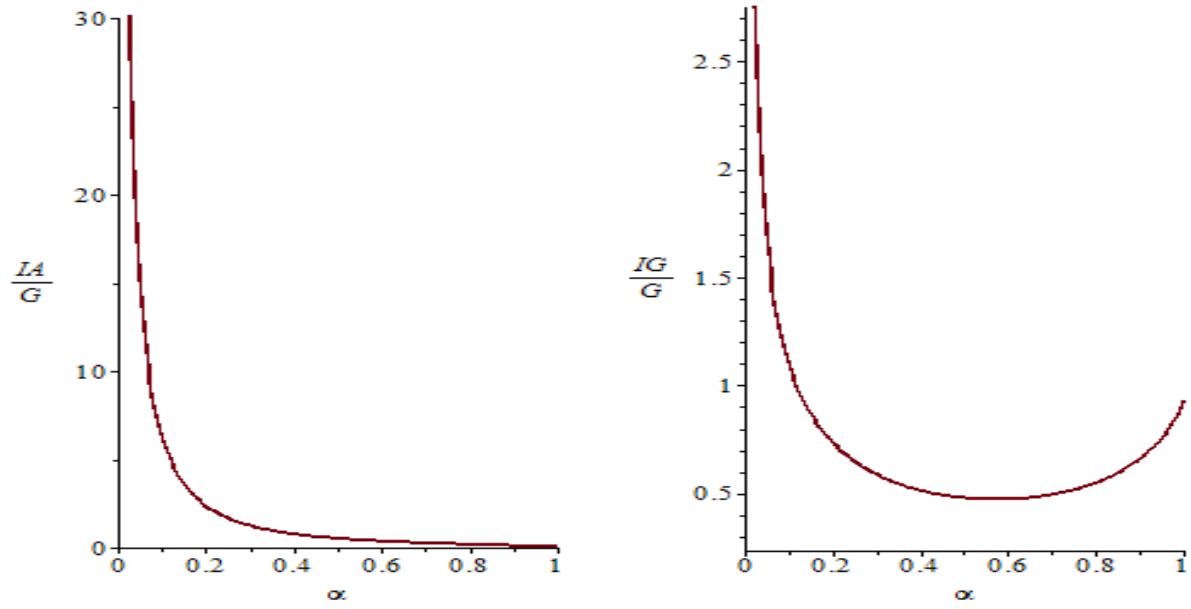
There is no direct way to study G and A as functions of α, but we can make numerical simulation for the following:

$$\frac{I_G}{G} = r + \gamma x \qquad (8)$$

$$\frac{I_A}{G} = rx + \delta_1 x + \delta_2 \qquad (9)$$

$$\frac{C}{G} = x^{1-\alpha} - (r + \gamma x) - (rx + \delta_1 x + \delta_2) > 0 \qquad (10) \qquad \Leftrightarrow r < \frac{x^{1-\alpha} - (\gamma + \delta_1)x - \delta_2}{1+x}.$$

Graph 3: investments relatively to α

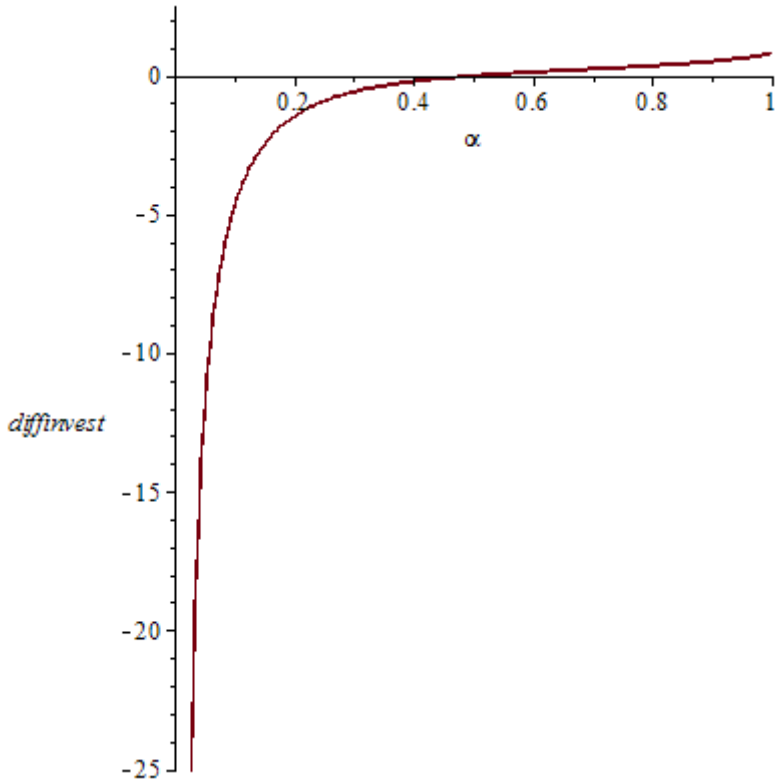


$$\rho = 0.04, \quad \delta_1 = 0.05, \quad \delta_2 = 0.03, \quad \gamma = 0.05$$

The curve of $\frac{I_A}{G}$ as a function of α is monotonic and decreasing; $\frac{I_G}{G}$ is decreasing for small values of α, and then increasing after a minimum. The results of the simulation above display high values of $\frac{I_G}{G}$ for the smallest values of α (when G is small relative to A), a minimum above α=½, and then highest values when G becomes the main factor of growth, and investing in G is an important factor for intertemporal utility in the "green growth".

In our simulation, the difference $(I_G - I_A)/G$ as a function of α tends to -∞ for α = 0, and displays a strong asymmetry: in absolute values, the difference is much larger far small α, when A dominates G, and more limited on the other side.

Graph 4: difference in investment relatively to α



Proposition 4: existence condition for a positive growth rate (sufficient conditions)

If $\rho + \delta_2 < \alpha\left(\frac{1-\alpha}{\rho+\delta_1+\gamma}\right)^{\frac{1-\alpha}{\alpha}}$ *and* $\frac{C}{G} > 0$,

Then there is a growing rate $r = -\eta(\rho - \alpha x^{1-\alpha} + \delta_2) > 0$ *with*

$$\frac{\dot{G}}{G} = \frac{\dot{A}}{A} = \frac{\dot{I_G}}{I_G} = \frac{\dot{I_A}}{I_A} = \frac{\dot{C}}{C} = r \text{ and } \frac{\dot{\lambda}_A}{\lambda_A} = \frac{\dot{\lambda}_G}{\lambda_G} = \rho - \alpha x^{1-\alpha} + \delta_2 < 0.$$

Note that $(10) > 0$ implies that $0 < r < \alpha x^{1-\alpha} - \delta_2$. Moreover, (10) is true if $\eta \leq 1$

See proof in appendix.

More analytical results on the sign of r

If we name $z = \rho + \delta_2$ and $y = \rho + \delta_1 + \gamma$, Proposition 1 and Proposition 3 tell us that:

i) if $z - \alpha\left(\frac{1-\alpha}{y}\right)^{\frac{1-\alpha}{\alpha}} = 0$,

ii) if $z-\alpha\left(\frac{1-\alpha}{y}\right)^{\frac{1-\alpha}{\alpha}}<0, then\ r>0$

iii) if $z-\alpha\left(\frac{1-\alpha}{y}\right)^{\frac{1-\alpha}{\alpha}}>0,$ then <0 .

We consider the case ii), so this characterization of the optimal solution at infinity shows the importance of the sign of the equation: $(\alpha)=z-\alpha\left(\frac{1-\alpha}{y}\right)^{\frac{1-\alpha}{\alpha}}$.

$\lim_{\alpha\to 0} t(\alpha)=-\infty$ if $y<1$;

$\lim_{\alpha\to 0} t(\alpha)=z$ if $y\geq 1$;

$\lim_{\alpha\to 1} t(\alpha)=z-1$;

$t'(\alpha)=0 \iff \alpha=1-y$;

$t(1-y)=z+y-1$.

In conclusion for the $y<1$ case:

a) for small values of α case ii) is true. That is logical because the production depends on the natural capital which is less important here; thus G is not a limit to growth;

b) if $z+y<1$, the case ii) is also true; in that case, the extent of disservices is limited, and A and G are growing in a balanced way

c) if $z+y>1$, and $z<1$, case iii) is true for intermediate values of α; in that case, A puts pressure on G and given the complementarity of A and G in production, the pressure breaks the growth dynamics and results in degrowth.

d) if $z>1$, there is α^* for that all $\alpha>\alpha^*$, $r<0$ (case iii)).

Note that regarding our parameters values we are in the case b).

3.2. Second case: when $\delta_1 = \delta_2 = 0$

In this part, it is assumed that the levels of A and G stocks impact jointly on the dynamics of A. The intuition is that the natural capital tends to accelerate the depreciation of the man-made capital at a stronger rate when ecosystems have already been perturbed by a high level of man-made capital. In other words, natural capital tends to generate more disservices when it is pushed out of its natural dynamics. In that case, rate δ at which man-made capital is depreciated is not constant, but a function of the natural capital H(G), and we consider a linear function H(G) = δG. Our problem can be formalized as follows:

$Max_{I_G I_A c} \int_0^{\infty} e^{-\rho t} U(C).dt$

s/t $\dot{G} = I_G - \gamma A,$ $\dot{A} = I_A - \delta AG,$ $G_0 \; and \; A_0$ are given

and $F(G,A) = C + I_G + I_A = G^{\alpha} A^{1-\alpha}.$

The Hamiltonian associated with an internal solution is:

$H = U(C) + \lambda_G(I_G - \gamma A) + \lambda_A(I_A - \delta AG).$

The first order conditions in the steady state are:

$\frac{\partial H}{\partial I_G} = -U'(C) + \lambda_G = 0,$ (2)

$\frac{\partial H}{\partial I_A} = -U'(C) + \lambda_A = 0,$ (3)

$\dot{\lambda}_G = \rho\lambda_G - \frac{\partial H}{\partial G} = \rho\lambda_G - U'(C).F_G + \lambda_A \delta A = 0,$ (11)

$\dot{\lambda}_A = \rho\lambda_A - \frac{\partial H}{\partial A} = \rho\lambda_A - U'(C).F_A + \lambda_A \delta G + \gamma\lambda_G = 0,$ (12)

$\dot{G} = I_G - \gamma A = 0,$ $\dot{A} = I_A - \delta AG = 0.$ (13)

Proposition 5: ***Existence of a steady state***

There is a steady state given by:

$$A, \text{ solution of } \quad (\rho+\gamma)(\delta A+\rho)^{1/(1-\alpha)} - (1-\alpha)\alpha^{\alpha/(1-\alpha)}(\delta A+\rho) + \delta A\alpha^{1/(1-\alpha)} = 0,$$

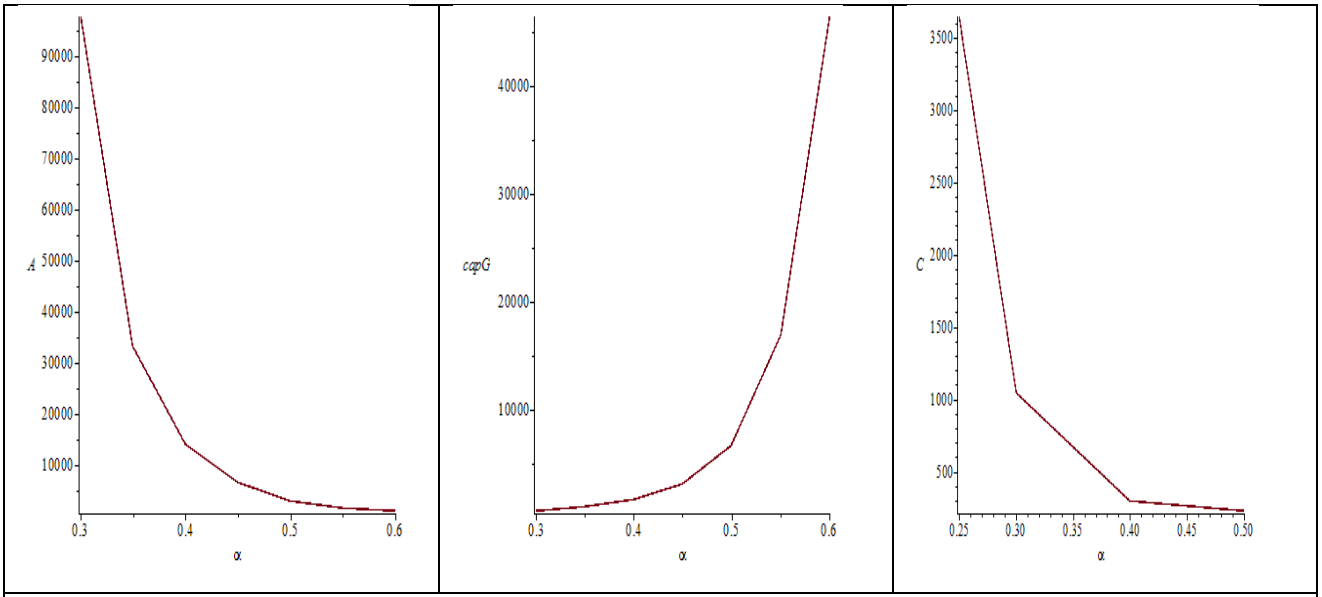
$$And \quad I_G = \gamma A, \qquad I_A = \delta GA, \qquad G = \frac{A\alpha^{1/(1-\alpha)}}{(\delta A+\rho)^{1/(1-\alpha)}},$$

The sufficient conditions to have a positive steady state are:

$$C = G^{\alpha}A^{1-\alpha} - \gamma A - \delta GA > 0 \text{ and } (\rho+\gamma)\rho^{\frac{1}{1-\alpha}} - (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\rho \leq 0.$$

It is not possible to study analytically these conditions. But numerical simulations can be done for any value of the parameters.

Graph 5: A, G and c relatively to $\boldsymbol{\alpha}$



$\boldsymbol{\delta = 0.0001, \gamma = 0.05, \rho = 0.04}$

In this case, the depreciation of A is driven both by its own value, and by the value of G. The consequence of this multiplicative effect is to stop the growth and the dynamics results in a steady state.

The graphs above allow displaying, with specific but meaningful values, the importance of natural capital G in the production technology. This results in a high level of investment IG, at the expense of consumption of C and of man-made capital A which both decrease as α

increases. The simulations show that for high levels of α (above 0.6), there is no real numerical solutions to the optimization process. Natural capital G has such a weight that A vanishes because G contributes to its discounting. Since the production technology depends on A (as a complementary factor in a homogeneous function of degree 1), the whole economy collapses.

As it is impossible to get general solutions to our model analytically, we will study specific cases that will allow finding analytical solutions from the equation that determines A.

- **For $\boldsymbol{\alpha = {}^{1}/_{2}}$,** we can have analytical value of A

From $(\rho+\gamma)(\delta A+\rho)^{1/(1-\alpha)} - (1-\alpha)\alpha^{\alpha/(1-\alpha)}(\delta A+\rho) + \delta A\alpha^{1/(1-\alpha)} = 0$ it comes (see proof appendix 5)

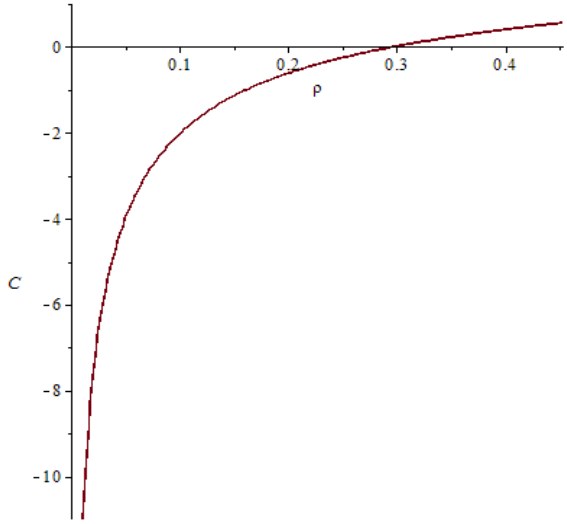
$$A = \frac{\sqrt{\frac{\rho}{\rho+\gamma}} - 2\rho}{2\delta}$$

and,

$$A > 0 \iff 0 < \rho < -4\gamma + \frac{\sqrt{16\gamma^2+16}}{\gamma} = \rho_2.$$

A is Always positive ($A > 0$) because $\gamma \in (0,1) \implies \rho > 1$ while the discount rate cannot exceed 1. Now that we have the assurance of the positivity of A (according to our parameters), check that of C. For this purposes, by simulating the values of C for γ = 0.1 the graph shows a positive values of C when ρ> 0.3. When the capitals have the same weight in the production ($\alpha = {}^{1}/_{2}$), the existence of C implies a strong preference for the present (high level of ρ) (see graph 6 below).

Graph 6: The variation of the long run consumption C relatively to the discount rate ρ

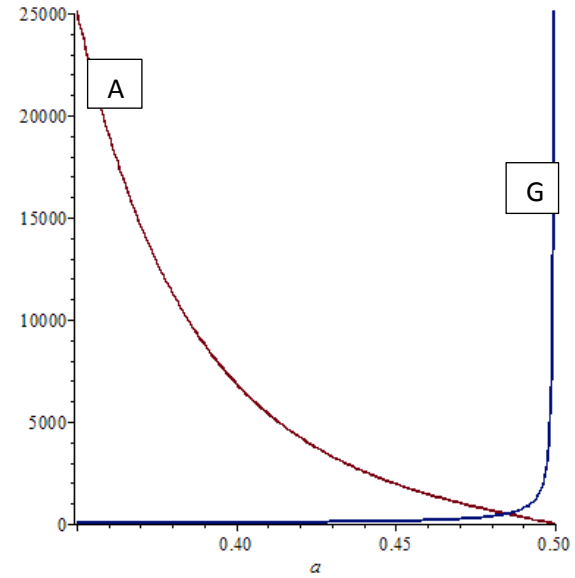


- **For $\rho \approx 0$**

$A > 0 \Leftrightarrow 0 < \alpha < \frac{1}{2}$ $thus$ if $\alpha \geq \frac{1}{2}$ and $\rho \approx 0$ $then$ $A < 0$ and in our $case, A = 0$ (See appendix).

A is positive as far as the weight of G in the production function does not exceed that of A ($\alpha \leq 1/2$). If G has a higher weight than A in the production function ($\alpha > 1/2$), A becomes null in the long run and the production also, due to the Cobb Douglas production function (see graph 7 below).

Graph 7: A, G and c relatively to $\boldsymbol{\alpha}$



The economic meaning of these first results remains questionable. More work is clearly needed in order to understand if this situation is due to modelling's artefact, that will imply to introduce changes in some of our hypothesis, or if it is possible to find satisfactory economic interpretations.

4. Discussion and conclusion

The models studied clearly highlight the importance of interaction in the evolution of both capitals and ensure the existence of an endogenous growth or steady state toward infinity.

In the linear case ($\boldsymbol{\delta = 0}$), there is an endogenous growth. Nevertheless, the dynamics can be negative and decrease to 0. It mainly depends on the level of negative interactions (disservice of G and environmental impact of A) that both capitals impose on each other, and thus on the value of parameters ($\rho, \gamma, \delta_2 \; et \; \delta_1$). A low level of negative interaction related to investments in A (γ) leads to an equilibrated growth of all variable A, G, C, I_A, I_G, except the adjunct variables. Whereas, if man-made capital destroys nature with a high amplitude (δ_2), this destruction breaks the growth and may result in degrowth.

The growth rate varies with α. It decreases from 0 to ½ and increases when $\alpha > 1/2$ (according to our parameters). The lowest growth rate corresponds to the situation when natural and man-made capital has the same weight in the production function. For high values of α, the natural capital increases faster than the man-made capital and the investment in G becomes higher than that of A too. All the economic growth is based on G and that ensures an economics' green growth. In others words, when natural capital has the high role in the production function, growth does not break and capitals do not break down like what Gylfason and Zoega (2006) have found in their study. However, this result appears as a mechanical consequence of the fact that, in our model, natural capital is not consumed as is the case in studies with exhaustible resources.

We note, in particular, that high depreciation of capital, as in the case when the man-made capital depreciation is based on natural capital, breaks the growth and leads to a steady state. Particular cases studied give interesting results. On the one hand, when the capitals have the same weight in the production, representative agent has to be impatient ($high \; value \; of \rho$) when the disservice causes by A on G is insignificant. On the other hand, when the agent is very patient and values the future more than the present (ρ≈0), A is positive if and only if the

weight of G in the production is inferior of that of A ($\alpha < 1/2$). However, in this case, the positivity of A does not ensure a positive C.

A few years ago, Partha Dasgupta (2008) had formulated serious criticism on how economists regard nature:

"*Nature did not appear much in twentieth century economics, and it doesn't do so in current economic modelling. When asked, economists acknowledge nature's existence, but most deny that she is worth much. I have professional colleagues who believe that the services nature provides amount at best to 2–3% of an economy's output, which is the share of agriculture in the GDP of the United States. Why, they ask, should one incorporate a capital asset of negligible importance in macro-economic models of growth and distribution?*"

In this paper we develop a framework to handle this issue and, as stated by Dasgupta, we found very limited literature offering insights to guide our work. When presented in a conference or a workshop, this paper received real interest from colleagues but we felt that they were somewhat surprised by the way we have chosen to represent nature as a capital which is neither consumed when involved in production, nor has a "natural" dynamics from itself. But after many attempts, these choices have appeared as the most relevant to study the issue of incorporating nature's services into economic dynamics and growth. Indeed, in the long run, the relation between economic dynamics and ecosystems is not – at least not only – an issue of (renewable) resource provision but of ecosystem services and disservices that may boost or hamper economic development. It turns out that ecosystems, if well preserved, play an important role in economic growth. Thus, this work should lead to greater attention to the impacts that productive investments, including development of territories, on ecosystems. It shows in particular that the forms that can take the interaction between different forms of capital can lead to hinder any growth.

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Appendix

Proof of the proposition 1: *if* $\left(\frac{\rho+\delta_2}{\alpha}\right)^{1/1-\alpha} = \left(\frac{\rho+\delta_1+\gamma}{1-\alpha}\right)^{-1/\alpha}$ *then a steady state exists.*

From the first order conditions, (2) and (3) give:

$$U'(C) = \lambda_G = \lambda_A > 0. \qquad \text{(A1.1)}$$

from (4) and (5),

$$\rho - F_G + \delta_2 = \rho - \alpha\left(\frac{A}{G}\right)^{1-\alpha} + \delta_2 = 0, \qquad \text{(A1.2)}$$

$$\rho - F_A + \delta_1 + \gamma = \rho - (1-\alpha)\left(\frac{A}{G}\right)^{-\alpha} + \delta_1 + \gamma = 0. \qquad \text{(A1.3)}$$

We have two equations with a single unknown variable $\frac{A}{G}$, so there is no steady state unless $\left(\frac{\rho+\delta_2}{\alpha}\right)^{1/1-\alpha} = \left(\frac{\rho+\delta_1+\gamma}{1-\alpha}\right)^{-1/\alpha}$.

Proof of proposition 2: *There is a unique solution A>0*

By deriving (2) and (3),

$$\frac{\dot{\lambda}_A}{\lambda_A} = \frac{\dot{\lambda}_G}{\lambda_G} = C\frac{U''}{U'}\frac{\dot{C}}{C} = -\frac{1}{\eta}\frac{\dot{C}}{C}\ , \qquad \text{(A2.1)}$$

with $\eta = -\frac{U'(C)}{U''(C)C}$: the inter-temporal elasticity of substitution in consumption.

From (4), (5) and (A1.1):

$$\rho - (1-\alpha)\left(\frac{G}{A}\right)^{\alpha} + \delta_1 + \gamma = \rho - \alpha\left(\frac{A}{G}\right)^{1-\alpha} + \delta_2. \qquad \text{(A2.2)}$$

Now prove that there is a unique solution $x = \frac{A}{G} > 0$ of the equation (A2.2):

remember that $a = \delta_1 + \gamma - \delta_2$, we are looking for $x \in (0, \infty)$ the zero of

$$f(x) = \alpha x^{1-\alpha} - (1-\alpha)x^{-\alpha} + a,$$

we have :

$$\lim_{x\to 0} f(x) = -\infty, \quad \lim_{x\to\infty} f(x) = \infty, \qquad f'(x) = \alpha(1-\alpha)(x^{-\alpha} + x^{-\alpha-1}) > 0,$$

then there is a unique solution to $f(x) = 0$ with $x > 0$. (The function is monotonous and crosses the horizontal axis once)

Some remarks on x:

- As $f(1) = -1 + 2\alpha + \mathrm{a}$,

$$\alpha < \frac{1-\mathrm{a}}{2} \Longrightarrow x > 1, \text{ and } \quad \alpha > \frac{1-\mathrm{a}}{2} \Longrightarrow 0 < x < 1.$$

- We want to know α influence. Remember that :

$$\frac{\partial x(\alpha)^{1-\alpha}}{\partial \alpha} = x^{1-\alpha}\left(-lnx + (1-\alpha)x^{-1}\frac{\partial x}{\partial \alpha}\right), \quad \frac{\partial x(\alpha)^{-\alpha}}{\partial \alpha} = x^{-\alpha}\left(-lnx - \alpha x^{-1}\frac{\partial x}{\partial \alpha}\right),$$

Then, by taking into account $\alpha x^{1-\alpha} - (1-\alpha)x^{-\alpha} + \mathrm{a} = 0$, we have:

$\frac{\partial x}{\partial \alpha} = -\frac{x(x^{1-\alpha}+x^{-\alpha}+\ln(x)\mathrm{a})}{\alpha(1-\alpha)(x^{1-\alpha}+x^{-\alpha})}$,

then

$$0 < \mathrm{a} < 1 - 2\alpha \Leftrightarrow \frac{\partial x}{\partial \alpha} < 0.$$

Proof of proposition 3

As $x = \frac{A}{G}$ is constant, we have:

$$\frac{\dot{G}}{G} = \frac{\dot{A}}{A} := r,$$

with r the growing rate of these variables.

From dynamics equations, we have

$$\dot{G} = I_G - \gamma x G,$$

and

$$x\dot{G} = I_A - \delta_1 x G - \delta_2 G,$$

then

$$\frac{\dot{G}}{G} = \frac{I_G}{G} - \gamma x \implies \frac{I_G}{G} = r + \gamma x,$$

and

$$x\frac{\dot{G}}{G} = \frac{I_A}{G} - \delta_1 x - \delta_2 \implies \frac{I_A}{G} = rx + \delta_1 x + \delta_2$$

and $\frac{I_G}{G}$ and $\frac{I_A}{G}$ are constants. Then,

$$\frac{\dot{I}_G}{I_G} = \frac{\dot{I}_A}{I_A} = r.$$

Since

$$G^{\alpha}A^{1-\alpha} = C + I_G + I_A\,,$$

we have,

$$x^{1-\alpha} = \frac{C}{G} + \frac{I_G}{G} + \frac{I_A}{G},$$

then,

$$\frac{C}{G} = x^{1-\alpha} - (r + \gamma x) - (rx + \delta_1 x + \delta_2).$$

By multiplying (12) by x, we get $\gamma x = -\alpha x^{2-\alpha} + (1-\alpha)x^{1-\alpha} - \delta_1 x + \delta_2 x.$

By replacing γx in $\frac{C}{G}$, $x^{1-\alpha} - (r + \gamma x) - (rx + \delta_1 x + \delta_2) > 0\ if\ r < \alpha x^{1-\alpha} - \delta_2.$

Remark that if $\eta < 1$ (10) is true and $r < \alpha x^{1-\alpha} - \delta_2$

Proof: $-\rho + \alpha x^{1-\alpha} - \delta_2 < \alpha x^{1-\alpha} - \delta_2$

$\Leftrightarrow\ -\rho < 0$

Moreover,

$r \coloneqq \frac{\dot{C}}{C}$.

Returning to (4) and (A2.1),

$r = -\eta(\rho - \alpha x^{1-\alpha} + \delta_2)$

Some remarks on r

- Variation relatively to α

$\frac{\partial r}{\partial \alpha} = \eta\left[x^{1-\alpha} + \alpha x^{1-\alpha}(-\ln(x) + (1-\alpha)x^{-1}\frac{\partial x}{\partial \alpha})\right]$,

Taking into account $\frac{\partial x}{\partial \alpha}$ given in remark 1 and replacing a ,

$\frac{\partial r}{\partial \alpha} = \eta x^{1-\alpha}\left[1 + \alpha\left(-\ln(x) - \frac{x^{1-\alpha}+x^{-\alpha}+\ln(x)\mathrm{a}}{\alpha(x^{-\alpha}+x^{1-\alpha})}\right)\right] = \frac{-\eta x^{1-\alpha}x^{-\alpha}\ln(x)}{x^{1-\alpha}+x^{-\alpha}}$,

Then

$$\alpha < \frac{1-\mathrm{a}}{2} \Leftrightarrow \frac{\partial r}{\partial \alpha} < 0\,, \qquad \alpha > \frac{1-\mathrm{a}}{2} \Leftrightarrow \frac{\partial r}{\partial \alpha} > 0\,.$$

- Variation relatively to a

$\frac{\partial r}{\partial \mathrm{a}} = \frac{x^{1-\alpha}}{x^{1-\alpha}+x^{-\alpha}}$,

Then

$$\frac{\partial r}{\partial \mathrm{a}} > 0\,.$$

Proof of proposition 4: Find conditions which satisfy that the growth rate r>0

$$r = -\eta(\rho - \alpha x^{1-\alpha} + \delta_2) > 0$$

To prove that $\rho - \alpha x^{1-\alpha} + \delta_2 < 0$, the equation (A2.2) can be written:

$$\rho - (1-\alpha)x^{-\alpha} + \delta_1 + \gamma = \rho - \alpha x^{1-\alpha} + \delta_2.$$

Let x^1 as $f_1(x) = \rho - \alpha x^{1-\alpha} + \delta_2 = 0, i.e.\ x^1 = (\frac{\rho+\delta_2}{\alpha})^{1/1-\alpha}$,

and x^2 as $f_2(x) = \rho - (1-\alpha)x^{-\alpha} + \delta_1 + \gamma = 0,\ i.e.\ x^2 = (\frac{\rho+\delta_1+\gamma}{1-\alpha})^{-1/\alpha}$,

as

$$\lim_{x\to 0} f_2(x) = -\infty\,, \quad \lim_{x\to\infty} f_2(x) > 0\,, \quad f'_2 > 0\,,$$

$$f_1(0) > 0, \qquad \lim_{x\to\infty} f_1(x) = -\infty, \qquad f'_1 < 0,$$

If

$\left(\frac{\rho+\delta_2}{\alpha}\right)^{1/1-\alpha} < \left(\frac{\rho+\delta_1+\gamma}{1-\alpha}\right)^{-1/\alpha}$,

Then

$\rho - \alpha x^{1-\alpha} + \delta_2 < 0,$

and we have a condition on the problem's parameters guaranteeing the value of $r>0$.

Proof of proposition 5:

(2) and (3) give :

$U'(C) = \lambda_G = \lambda_A > 0,$ (A5.1)

(13) gives:

$I_G = \gamma A, \qquad I_A = \delta G A\ ,$ (A5.2)

(11) and (12) imply that :

$\rho - F_G(A,G) + \delta A = 0,$ (A5.3)

$\rho - F_A(A,G) + \delta G + \gamma = 0,$ (A5.4)

(A5.3) and (A5.4) give:

$-(1-\alpha)\left(\frac{A}{G}\right)^{-\alpha} + \delta G + \gamma = -\alpha\left(\frac{A}{G}\right)^{1-\alpha} + \delta A;$ (A5.5)

And (A5.4) gives:

$G = \frac{A\alpha^{1/(1-\alpha)}}{(\delta A+\rho)^{1/(1-\alpha)}},$ (A5.6)

replacing (A5.6) we have the following equation for the value of A :

$f(A) = (\rho+\gamma)(\delta A+\rho)^{1/(1-\alpha)} - (1-\alpha)\alpha^{\alpha/(1-\alpha)}(\delta A+\rho) + \delta A\alpha^{1/(1-\alpha)} = 0\ .$ (A5.7)

We have the following properties of f

$f(0) = (\rho+\gamma)\rho^{\frac{1}{1-\alpha}} - (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\rho$,

with $f(0) \leq 0$ *assumed*,

$f'(A) = \frac{\rho+\gamma}{1-\alpha}\delta(\delta A+\rho)^{\frac{1}{1-\alpha}-1} - (1-\alpha)\alpha^{\frac{\alpha}{1-\alpha}}\delta + \delta\alpha^{\frac{1}{1-\alpha}}$,

Moreover it is easy to see that $\alpha^{1/1-\alpha} - (1-\alpha)\alpha^{\alpha/1-\alpha} = -\alpha^{\alpha/1-\alpha} + 2\alpha^{1/1-\alpha} > 0$ *if* $\alpha > \frac{1}{2}$ then $f'(A) > 0$.

Moreover $\lim_{A\to\infty} f(A) = +\infty$.

Then, there is A > 0 solution of (A5.7), and if $\alpha > \frac{1}{2}$ then A is unique.

The steady state is given by (A5.1), (A5.2), (A5.6) and A solution of (A5.7).

- **For $\alpha = {}^{1}/_{2}$**

$(\rho+\gamma)(\rho+\delta A)^2 - \frac{1}{4}(\rho+\delta A) + \frac{\delta A}{4} = 0;$

$(\rho+\gamma)(\rho+\delta A)^2 - \frac{\rho}{4} = 0$

$$A = \frac{\sqrt{\frac{\rho}{\rho+\gamma}} - 2\rho}{2\delta}$$

$$A > 0 \iff \sqrt{\frac{\rho}{\rho+\gamma}} - 2\rho > 0 \iff \frac{\rho}{\rho+\gamma} > 4\rho^2 \iff 4\rho^2 + 4\gamma\rho - 1 < 0;$$

$\rho_1 = -4\gamma - \frac{\sqrt{16\gamma^2+16}}{\gamma}$ and $\rho_2 = -4\gamma + \frac{\sqrt{16\gamma^2+16}}{\gamma}$

Then $A > 0 \iff 0 < \rho < \rho_2$

Estimate ρ_2 when γ=1

$\iff \rho_2 = \frac{-1+\sqrt{2}}{4} \approx 1.65$

$G = \frac{A}{4(\delta A+\rho)^2} = \frac{\left[\sqrt{\frac{\rho}{(\rho+\gamma)}} - 2\rho\right](\rho+\gamma)}{2\delta\rho}$

C > 0 if $A\left[\left(\frac{G}{A}\right)^{\alpha}-\gamma-\delta G\right]>0$

$\Leftrightarrow \left[\frac{4(\rho+\gamma)}{\rho}\right]^{1/2}-\gamma-\frac{\left[\sqrt{\frac{\rho}{\rho+\gamma}}-2\rho\right](\rho+\gamma)}{2\rho}>0$

$\Leftrightarrow \left(\frac{\rho+\gamma}{\rho}\right)^{1/2}+\rho-\frac{\left(\frac{\rho}{\rho+\gamma}\right)^{1/2}}{2\rho}>0$

- **Estimations when $\boldsymbol{\rho \approx 0}$**

if $\rho = 0$, then the equation that gives the value of A becomes :

$\gamma(\delta A)^{1/1-\alpha}-(1-\alpha)\alpha^{\alpha/1-\alpha}(\delta A)+\delta A\alpha^{1/1-\alpha}=0$

$\Leftrightarrow \delta A\left(\gamma\delta A^{\,1/1-\alpha-1}-(1-\alpha)\alpha^{\alpha/1-\alpha}+\alpha^{1/1-\alpha}\right)=0$

$\Leftrightarrow A=0 \;\; or \;\; \gamma(\delta A)^{\alpha/1-\alpha}=(1-\alpha)\alpha^{\alpha/1-\alpha}-\alpha^{1/1-\alpha}$

$A>0 \Leftrightarrow 0<\alpha<\frac{1}{2} then\ if\ \alpha>\frac{1}{2}\ and\ \rho\approx 0\ then\ A<0\ and\ in\ our\ case\ A=0$

Case where $0<\alpha<\frac{1}{2}$

C > 0 if $A\left[\left(\frac{G}{A}\right)^{\alpha}-\gamma-\delta G\right]>0$

$\Leftrightarrow \frac{\alpha^{\alpha/1-\alpha}}{(\delta A)^{\alpha/1-\alpha}}-\gamma-\frac{\delta A\alpha^{1/1-\alpha}}{(\delta A)^{1/1-\alpha}}>0$

$\Leftrightarrow \frac{1}{(\delta A)^{\alpha/1-\alpha}}\left[\alpha^{\alpha/1-\alpha}-\gamma(\delta A)^{\alpha/1-\alpha}-\alpha^{1/1-\alpha}\right]=\frac{1}{(\delta A)^{\alpha/1-\alpha}}\left[\alpha^{\alpha/1-\alpha}-(1-\alpha)\alpha^{\alpha/1-\alpha}\right]>0$

$\Leftrightarrow \alpha\frac{1}{(\delta A)^{\alpha/1-\alpha}}\,\alpha^{\alpha/1-\alpha}>0$

Chapter 5: General conclusion

Conclusion générale

La prise de conscience de l'importance des écosystèmes et des services qu'ils procurent à la société date de la fin des années 1990 avec les travaux majeurs de Costanza et al. (1997) et Daily (1997). La décennie 2000-2010 est marquée par deux grandes expertises internationales ayant mis en lumière les représentations « sociétés-nature » : le MEA (2001-2005) et le TEEB (2007-2010); suivi de l'institutionnalisation en 2010 de l'année internationale de la biodiversité. La question de la protection des écosystèmes et des espèces qu'ils incluent est aujourd'hui au cœur des grandes préoccupations internationales. Celles-ci se traduisent en effet par la consécration de la décennie 2011-2020 à la biodiversité tandis qu'une encyclique papale exclusivement consacrée à l'environnement "*LAUDATO SI*" (une première dans l'histoire) invite l'ensemble de la communauté internationale à agir en urgence pour la sauvegarde de la biodiversité.

Depuis les travaux du MEA mettant en évidence la dégradation de très nombreux écosystèmes et les menaces pesant sur les services dont dépend la survie d'une grande partie de la population mondiale; la littérature sur les écosystèmes et les fonctions du paysage dans les pays développés s'est développée de façon importante. Toutefois, en dépit du fait qu'une grande part de la diversité biologique se trouve dans les pays en développement, et que les populations de ces pays dépendent fortement des écosystèmes pour leurs besoins de bases (Pascual et al., 2010; Christie et al., 2012), la recherche y reste à ce stade peu développée (Christie et al., 2012). En conséquence, il est nécessaire de développer une meilleure compréhension de la relation entre les populations et les écosystèmes dans ces pays afin de cibler des politiques plus adaptées au contexte.

Cette thèse y a contribué en s'intéressant aux services écosystémiques liés à un contexte particulier: le parc urbain Bãngr-weoogo de Ouagadougou (Burkina Faso). Pour cela, elle utilise une approche pluridisciplinaire dans le but d'éclairer non seulement les décideurs politiques mais aussi les populations. Elle vise à mettre en exergue l'importance de la biodiversité et des aménités vertes de cet espace semi-naturel mais aussi l'importance des écosystèmes dans la dynamique économique. Finalement, les résultats de la thèse prônent une conservation de cet espace et la création de bien d'autres espaces similaires pour le bien-être des populations urbaines. Le chapitre 1 tente de clarifier le concept de services écosystémiques et de mettre en lien les différentes parties de la thèse afin de la rendre cohérente. Il définit le concept de services écosystémiques, rappelle les discussions autour du

concept et précise les enjeux pour les pays en développement. La thèse embrasse différents points soulevés dans la littérature à savoir les préférences pour la biodiversité et les aménités vertes à travers l'évaluation économique et le rôle des écosystèmes dans la dynamique de développement. Elle se veut à la fois empirique et théorique. La partie empirique a analysé d'une part les préférences des visiteurs du parc afin de mieux appréhender les caractéristiques qui ont le plus d'intérêt pour eux ; une des caractéristiques étant le niveau de biodiversité et, d'autre part, l'importance du parc urbain dans le choix de localisation résidentiel dans une ville de plus en plus urbanisée avec pour corolaire des coûts de logement et de déplacement élevés. La partie théorique visait à comprendre, à travers un modèle de control optimal, le rôle de la préservation des écosystèmes fonctionnels dans la dynamique économique.

Le chapitre 2 montre que les visiteurs du parc ne considèrent pas qu'il y ait un conflit entre les loisirs et la conservation de la biodiversité. Il était important d'évaluer les préférences des visiteurs pour une meilleure gestion de cet espace. Il était important de connaitre les préférences des visiteurs pour une meilleure gestion de cet espace. Grâce à une enquête réalisée auprès de 500 visiteurs, nous avons mis en évidence une préférence pour une augmentation de 10% du niveau de biodiversité pour les 5 prochaines années. En outre, les visiteurs sont en moyenne contre une éventuelle suppression des restrictions récréatives et ne trouvent pas le parc encombré alors qu'il reçoit plus de 300.000 visites par an et ce nombre ne fait que croitre.

Le chapitre 3 a mis en évidence l'importance des aménités vertes (parc urbain) dans le choix de localisation résidentiel des habitants de la ville de Ouagadougou. Elle a permis de comprendre le compromis entre vivre près des aménités vertes et près de son lieu de travail dans un contexte de forte urbanisation avec des infrastructures de transport moins développées et une pression environnementale perceptible. Les résultats ont montré une préférence pour la réduction de la distance au parc et la distance au lieu de travail. Le résultat peu attendu était que la réduction de la distance du parc procure un bien-être supérieur à celui de la distance au lieu de travail. Quant à la présence de proches dans la zone d'habitation, elle a reçu le consentement à payer le plus élevé. Cette étude a eu des implications pour la planification urbaine. Elle a fourni la preuve que, dans le cas du Burkina Faso, les espaces verts sont considérés comme attrayant et que les efforts de conservation ciblant ces espaces sont susceptibles de rencontrer un large soutien public.

Le chapitre 4, basé sur une étude théorique, s'est intéressé la question du rôle des écosystèmes dans la dynamique de développement dans un cadre de modèle de control optimal. La nature est considérée ici comme un capital associé à un autre, le capital physique pour produire un bien de consommation. Il a montré l'importance des interactions entre les deux capitaux ; interactions pouvant conduire vers un état stationnaire ou une croissance (ou décroissance) équilibrée. Sous nos hypothèses, dans le cas où il y'a de la croissance, le taux est relativement plus élevé quand la nature joue un grand rôle ou peu de rôle dans la production comparativement aux situations où les deux capitaux ont pratiquement le même poids.

En dépit des efforts importants fournis pour obtenir des résultats crédibles, il faut souligner un certain nombre de limites dans ce travail de recherche qui feront l'objet de futures améliorations. Si le *choice experiment* semble être la méthode la plus adaptée au regard d'autres outils d'évaluation dans le domaine environnemental, il n'en demeure pas moins qu'il présente quelques limites (Voir tableau 3 du chapitre 1).

Par ailleurs, la taille de l'échantillon ne permet pas une généralisation des résultats (au plan au plan local pour le chapitre 3). En outre, bien que le revenu soit une variable clé dans les préférences pour les services écosystémiques, elle n'a pas été considérée en absolu dans cette étude en raison de la difficulté de collectes des données. Nous avons plutôt considéré des intervalles de revenus ; chose qui ne permet pas de mettre capter le niveau de vie réel car ne pouvant pas être rapporté au nombre de membres des familles par exemple.

La question de l'extension de l'enquête du chapitre 2 au non visiteurs se pose également. Quel est l'apport d'une telle extension dans l'analyse? Il est clair que le fait de n'enquêter que les visiteurs conduit potentiellement à ne s'intéresser d'emblée qu'à ceux qui ont déjà une préférence pour le parc. Bien que notre souci fût de nous concentrer sur la population qui connait mieux le parc (à savoir les visiteurs), il n'en demeure pas moins qu'un non-visiteur peut avoir une bonne connaissance de cet environnement mais ne pas le fréquenter pour des raisons diverses. Des travaux futurs devraient en conséquence être orientés vers leur prise en compte. Pour le chapitre 3, la taille du logement en superficie et le cout ou le temps de déplacement auraient été de meilleurs indicateurs. Malheureusement, le logement est généralement perçu en nombre de pièces et les déplacements en distance.

Pour le chapitre 4, il serait peut-être intéressant d'assouplir nos hypothèses (nature hostile, non régénération naturelle du capital) et étudier la trajectoire du modèle pour de meilleures interprétations.

General discussion

The awareness of the importance for the society of ecosystem services (ES) dates from the end of the 1990s with the major works of Costanza et al. (1997) et Daily (1997). The decade 2000-2010 was marked by two major international expertise that emphasized the representations of the link society-nature: the Millennium Ecosystem Assessment (2001-2005) and The Economics of Ecosystems and Biodiversity (2007-2010), then institutionalization in 2010 of the International Year of Biodiversity. The issues of ecosystem conservation and the species they include are now at the heart of international concerns. Indeed, this phenomenon led to the decision to declare 2011-2020 the "decade of biodiversity"; while a papal encyclical devoted exclusively to the environment *"LAUDATO SI"* (a first in history) calls on the entire international community to act urgently to preserve biodiversity.

Since the MEA that highlighted the degradation of many ecosystems and identified threats to services on which the survival of much of the world's population depends, the literature on ecosystems and landscape functions has grown significantly in developed countries. However, despite the fact that much of the biological diversity is located in developing countries, and that the population of these countries is highly dependent on ecosystems for their basic needs (Pascual et al., 2010; Christie et al., 2012), research on ES still remain at an early stage in these regions (Christie et al., 2012). It is therefore necessary to develop a better understanding of the links between people and ecosystems in these countries in order to better target policies.

This thesis contributes to filling this gap by focusing on ecosystem services related to the urban park Bãngr-weoogo of Ouagadougou (Burkina Faso). For this, it uses a multidisciplinary approach in order to answer to many questions and inform policy makers and Ouagadougou citizen. It aims to highlight the importance of biodiversity and green amenities of this semi-natural space but also the importance of ecosystems in economic dynamics. Finally, the results of the thesis recommend the conservation of this space and the creation of many other similar areas for the wellbeing of urban populations. Chapter 1 attempts to clarify ecosystem services concept and link the different parts of the thesis in order to make it consistent. It defines the ecosystem services concept, reminds the discussions around it and specifies the issues for developing countries. The thesis embraces different points raised in the literature such as i) the preferences for biodiversity and green amenities

through economic evaluation and ii) the role of ecosystems in the dynamics of development. These issues are addressed using both theoretical and empirical approaches. The empirical part analyzes, on the one hand, preferences of visitors for the characteristics of the park (chapter 2) (one characteristic is the level of biodiversity) and, on the other hand, the importance of the urban park in the residential location choice (chapter 3). The theoretical part aims at understanding, through an optimal control model, the role of the preservation of ecosystem functions in economic dynamics (chapter 4). Chapter 2 demonstrates that park visitors do not consider that there is a conflict between outdoor recreation and biodiversity conservation. It was important to evaluate the preferences of visitors for better management of this space. Through a survey of 500 visitors, we demonstrate a preference for a 10% increase in the level of biodiversity for the next five years. In addition, visitors prefer the maintenance of current recreational restrictions that allow traditional recreation activities, but are against a possible removal of restrictions that would affect biodiversity such as hunting. Finally, they do not find the park crowded although it receives over 300,000 visits per year. Chapter 3 highlights the importance of green amenities (urban park) in the residential location choice of the inhabitants of Ouagadougou. It contributes to understanding the tradeoff that inhabitants make between living near green amenities and near their workplace, in a context of high urbanization with weak transport infrastructures and high environmental pressure. The results show a preference for reducing the distance of the residence to the park as well as to the workplace. The unexpected result was that reducing the distance to the park brings a higher wellbeing than reducing the distance to the workplace. Nevertheless the presence of relatives in the living area receives the highest willingness to pay. This study has implications for urban planning. It provides evidence that, in developing countries, the green areas are considered attractive. The conservation of existing green areas and the creation of new ones are therefore likely to encounter large public support. Chapter 4, based on a theoretical study, focuses on the role of ecosystem conservation in the development dynamic through an optimal control model. Nature is considered here as a capital, which combined with physical capital produce a final good. It shows the importance of interactions between the two capitals that may lead to a steady state or balanced growth (or degrowth). Under our assumptions, if there is growth, the rate is relatively higher when the capitals have an unbalanced role in the production compared to situations where both capitals have almost the same weight.

This work presents a number of limits which will be subject to future improvements. If the choice experiment seems to be the most appropriate method compared with other

environmental valuation methods, it has some limits (see table 3 in Chapter 1). Furthermore, the sample size does not allow for generalization of the results (even at local level in the chapter 3). Moreover, the effect of income, which is a main variable in preferences for ecosystem services, could not be considered properly in this study due to data collection difficulties. Indeed, we have used income intervals, which do not allow capturing the real standard of living because it can't be related to the number of family members. The question of the extension of the survey of chapter 2 to non-visitors of the park also arises. It is clear that interviewing visitors only led to focus on people who already have a preference for the park. Although our concern was to focus on the people who best know the park (visitors), it is true that a non-visitor could also have preferences for this space. In Chapter 3, other housing characteristics could have been evaluated, such as housing size or travel cost or time. Unfortunately, housing is generally perceived in number of rooms and the travel in terms of distance. In Chapter 4, in order to better characterize the dynamics of the model, it would be interesting to relax some of our assumptions (hostile nature, non-regeneration of natural capital, non-consumer use).

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Les services écosystémiques dans les économies en développement: gestion, valeurs et dynamique économique

Résumé

Les travaux présentés dans cette thèse portent principalement sur l'évaluation économique des services écosystémiques, dans un pays en développement où les questions environnementales sont considérées comme étant moins prioritaires. L'introduction générale permet de définir les principaux concepts mobilisés et resitue les débats académiques autour de l'évaluation économique des services écosystémiques. Les deux chapitres suivants s'appuient sur un terrain spécifique: le parc urbain Bãngr-weoogo à Ouagadougou (Burkina Faso). Le premier analyse les préférences des visiteurs du parc pour la biodiversité et les activités récréatives à travers une étude empirique basée sur la méthode du *choice experiment*. Le second étudie, avec une méthode similaire, l'importance des aménités vertes dans le choix résidentiel des habitants de la ville de Ouagadougou qui, à l'image de nombreuses villes des pays en développement, connait une forte urbanisation dont les conséquences se font ressentir tant au niveau des coûts de logement et de déplacement, qu'au niveau environnemental. Le dernier chapitre, qui généralise et analyse de manière théorique la première étude, intègre la question de l'importance économique des écosystèmes dans un modèle de croissance. Sa principale originalité est de traiter de façon symétrique des services et dis-services liés aux écosystèmes pour analyser les conditions de convergence vers une croissance équilibrée ou un état stationnaire.

Mots clés : biodiversité, choice experiment, évaluation économique, modèles de croissance, parc Bãngr-Weoogo, services écosystémiques

Ecosystems services in developing economies: management, values and economic dynamic

Abstract

This thesis focuses on the economic valuation of ecosystem services in developing countries where environmental issues are considered a low priority. The general introduction defines the key concepts and presents the academic debates on the economic valuation of ecosystem services. The following two chapters deal with a specific case study: the urban park Bãngr-Weoogo in Ouagadougou (Burkina Faso). The first one analyzes the preferences of park visitors for the biodiversity and recreational activities through an empirical study based on the choice experiment method. The second one, with a similar method, analyzes the importance of green amenities in the residential location choice of Ouagadougou city inhabitants. This city, like many cities in developing countries, experiences a strong urbanization that has consequences in terms of housing and travel costs and in terms of environmental quality. The last chapter, which generalizes and analyzes theoretically the first study, integrates the importance of ecosystems in an economic growth model. Its main originality is to treat symmetrically ecosystem services and disservices to analyze the convergence conditions towards a balanced growth or a steady state.

Key words: biodiversity, choice experiment, economic valuation, growth models, Bãngr-weoogo Park, ecosystem services

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